FOREST FIRE CONTROL

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Returning to India after an absence of several years, I find the same old problems of forest administration still largely unsolved, but with the deterioration in certain forest tracts brought about by war-time fellings and subsequent civil disturbances, there is a new urgency in finding the right solution, particularly in the forests in the catchments of rivers now being utilized for irrigation and power projects. These now have a far higher human and industrial investment value than they ever had before simply as forest tracts. Taking any of the major reservoirs or high dams which are in themselves gigantic engineering tasks, the cash value invested in them can quite legitimately be booked against the catchment which finds the water. For instance a catchment of 400 square miles has a dam built worth Rs. 4 crores. The safety and, therefore, the investment value of that 4 crores is dependent upon the erosion control in the 400 square miles. If the catchment is mostly, let us say, badly mutilated *sal* scrub honeycombed with gullies, its value even in overcrowded areas is probably not more than Rs. 30 to 50 per acre, but almost overnight its value has been stepped up to Rs. 156 per acre by virtue of the new investment made in the water which it supplies.

The old idea about forests was that any sort of forest cover was an insurance against erosion, but the condition of some of the forests I have recently been examining belies this convention, which must be discarded along with some other old Shibboleths. If the forest department maintains, as it should, that forest is the best preventive of erosion, then it must hastily put its house in order and make quite certain that the forests it has charge of are in the best possible condition, not only in terms of forest production, but also in terms of water conservation, for this is the item which has placed a new high level on the value to the public of the forest in these important catchments.

Inevitably the cry goes up from the forest staff; "We can't stop the fires, and it is the fire damage plus the grazing damage which causes the heavy erosion". There is, therefore, little to be gained in theorising over investment values unless we can find an answer to the fire problem. It seems to me that there are two main lines of approach. One lies in the education of the villager towards what the forest estate really means to himself, his family, and the water users away downstream. The other lies within the department in a renewed attack upon the fire problem as it actually exists in any given area.

To deal first and quite briefly with the educational side, one has to admit that none of the forest departments throughout India have been signally successful in getting any preparatory educational message across to the villagers ahead of the various forest concessions or changes in forest management, the success of which depended upon the goodwill and understanding of the people affected. The gap between the departmental cadre and the villager remains as big as ever it was, except in a very few instances where the personal interest and drive of an individual officer has established a better understanding between them. There is, however, one strong hope, and that lies in the Community Development activities in the various provinces. The basic strategy in this is that a group of highly trained specialists each in his own line, such as irrigation, agriculture, co-operatives, health, etc., should form a team which deals with a "project area" of say one quarter of a civil district, and within this area, every five villages has a contact man who works closely with the school teachers, *panchayats*, and the cultivators themselves to get the various specialists' messages and instructions across to them. In this approach there are two obvious advantages, firstly concentration of effort, and secondly concentration of specialist knowledge. But nowhere amongst

these projects have I heard of a forest officer amongst the team, and enquiries from senior forest officers have been met with the explanation that it wasn't their job and that they had not been asked to take any part. The forest department appears to be missing this bus, but I should have thought that it was a very good bus to catch. Here is a vehicle for the eduction of the villager in just those points which he should be taught regarding the value of the forest to himself and the country, and the care which the forest needs from him.

Now let us turn to the more practical matter of fire control within the limits of existing conditions, and without waiting for the leaven of education to improve matters for us. I was much impressed by the article on "Forest Fires" in the Oct. 1953, *Indian Forester* by my old friend Mr. M. Hakimuddin, whose hunting exploits and practical forest knowledge are still a tradition in Saharanpur and Dehra Dun districts. He makes out a very strong case for the early and protective controlled burning of the forests before they reach their most inflammable condition in mid-summer. Most of us will agree with him. But if the answer were a simple one, I feel sure that it would have been adopted already on a much wider scale than it has been. What then are the difficulties which prevent its adoption ?

Within the geographical range of each of our major species, taking *sal,* teak, or pine, there are certainly blocks of forest which lend themselves to a regime of early burinng, but there are probably as many more which can't be burnt when you want to burn them for reasons of age class distribution, admixture of different undergrowth species, the demands of forest work such as resin tapping, uncertain climatic conditions which upset the average routine of seasonal desiccation, or other cogent reasons which every forest officer can trot out in an argument.

Taking the *Pinus longifolia* belt as an example of the slow evolution of protective burning :—when I first worked in Rawalpindi, Jerram and Glover had by 1923 established the controlled winter burning of the older pole crops as a feasible proposition and reduced it to a working plan prescription, but the older stands opened for seeding fellings and surrounded with seedlings, and the fully regenerated compartments from which most of the seed-bearers had been removed, were still being rigidly protected in the pious hope that fire could be kept out for a further 10 or 15 years. In 1924 I was tentatively putting fire through various patches of regeneration to see what could be done. With extremely keen supervision it was possible to run a fire through quite small saplings, even of 3 to 5 feet in height, with some preliminary clearance by hand of needle accumulations from the lower branch whorls. At that point also entered Carrington Turner from Dehra Dun to study our Punjab fire technique, and he was so convinced of its possibilities that on his return to the U.P. he got this drill adopted, even for young regenerated areas. Where the work had first been demonstrated, however, it took some years before the senior officers would agree to this, and in the interval Rawalpindi lost a good many of its fully regenerated blocks in holocausts of fire in 1926 and in the early thirties. The senior officers realized fully that although a careful small-scale demonstration can be made to succeed, the standard of performance is poorer once the control of fire has been reduced to a drill and applied throughout a whole forest division by a subordinate staff unsupervised. In the case of the village *chir* pine forests of Kangra and Hoshiarpur the standard of performance with which one had to be satisfied was even lower, whereas in the Jaunsar and Garhwal areas, the large compact blocks of *chir* pine clearly lend themselves to the treatment of early burning, in fact until I read Mr. Hakimuddin's recent article, I fondly imagined that this was now a routine practice governed by working plan prescriptions !

In the case of those *sal* forest areas which are now of major importance for water conservation, and particularly where the rate of silting is likely to endanger the efficiency of the reservoir by shortening its useful life, the possibility of effecting better protection by early

burning of piece-meal patches rather than waiting for a holocaust of fire in the heat of summer certainly deserves careful study and demonstration. Given a reasonable chance of light summer rainstorms following fire, this will help the burnt coppice shoots and shrubs and grass stumps to produce a flush of fresh green ahead of the real monsoon downpours, and so protect the soil from erosion. On the other hand where the grazing is punishingly heavy, early burning will produce a fresh green flush of grass growth early in the hot dry season and this will be greedily browsed. Will the end result not be that less fire damage but heavier grazing in the dry season will so exhaust the forest, that it will in fact retrograde ecologically and finish up as a mass of unpalatable weeds such as *Lantana* and *Adhatoda vasica* ?

Close analysis of the available old survey maps and of more recent maps made from air photos, plus the evidence of the photos themselves, shows pretty clearly that in those Chota Nagpur *sal* forests which were previously *zamindari* and have now become government protected forests, the gully heads have been making alarming headway within the tree covered area. A gain of 200 feet in new length for a single gully head as between the survey record of 1929 and the air-made sheets of 1950 is by no means uncommon, but the really dangerous feature, and one less easy to measure, is the increase in the over-all perimeter length of rotting bank which is provided by this head cutting bank and by its tributaries extending in an ever widening perimeter. The deterrent effect of the existing *sal* coppice, which is everywhere open, badly hacked about, browsed and burnt, is fairly small in terms of building up a humus, and apparently not even very effective in its roots holding the gully banks together. In fact, as a guarantee for the continued safety of a tremendous investment in utilizable water – that is to say, a sustained delivery of silt-free run-off and a smoothing out of high peak floods – these resumed *zamindari* forests strike me as being a singularly poor bargain for the engineer whose fine new ponds are likely to become silted in a comparatively short period.

One of the main reasons for lighting the summer fires is to gets a clean patch of ground beneath each *mahua* (*Bassia latifolia*) so that its flowers and fruit can be collected from the ground without too much trouble.

To the poorer villagers, particularly in years of shortage, the *mahua* crop is of considerable value, though one is somewhat sceptical about its real contribution to the food of the nation. There is something of religious significance in the custom which would probably cause an outcry if one were to suggest felling those which lie deepest in the forest and farthest from the village as a step towards better land management. If it were not mixed up with religious beliefs, it would seem a perfectly reasonable proposal to cut out these few *mahua* trees whose presence in blocks of otherwise pure *sal* is endangering both the water conservation value and the commercial forest value of the estate. If there really is a need for the *mahua*, then its cultivation should be taken up as a hedgerow species in and around the fields nearer the village, as in fact the more provident cultivators a few miles down the valley are already doing by planting orchards of *mahua*, mango and *Terminalia arjuna.*

In the blocks of *sal* which have previously been reserved forest, and where protection and conservative management have been the rule, the erosion is of course very much less, and even in a fairly deeply gullied terrain the formation of fresh gullies and the eating back of the main gully heads is so slow that it need not give cause for alarm to the engineers. It is in such forests that controlled burning should give good results, as it gives a better prospect of an all-the-year-round ground cover where previously the summer fires have undoubtedly left the forest floor exposed to serious sheet erosion at the beginning of the monsoon.

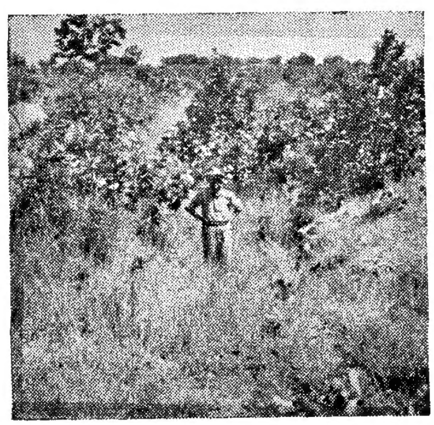
It is conceivable that an early burning programme, even in these better forests, may fail in certain years owing to unseasonal rain causing delay in drying out, so that the transitional period from wet to dry is telescoped and shortened, and there is literally not enough

time for protective burning before the forest has become highly inflammable. There is also the labour problem of getting the burning done just when the local cultivators are busy with their winter crops ; it is conceivable that in certain years it may not be possible to recruit the labour for protective burning. Against such emergencies we shall still need the rest of our fire-fighting technique such as fire-lines, watchers, look-outs, etc., so we cannot afford to scrap any of the existing fire-fighting arrangements, even after two or three years of successful early burning. Where we can progress is in giving a fair trial to early burning where it has not previously been employed.

The main point to emphasize about any demonstration of early or preventive burning is that you must never attempt to burn more ground than you have labour to control while burning. It is better to be safe than sorry, and if the forest floor is at all inflamable, there is always the chance that a sudden change of wind may turn your "controlled" fire into a really dangerous one. As an additional argument in favour of real early burning there is the knapsack pressure burner now on the market, somewhat larger than the kind used by painters to burn paint off woodwork, and with a longer fixture for the burner so that it can be directed while walking onto each individual grass clump in turn. Even if the ground cover is not fully inflammable, the drier parts of it can be greatly reduced with this equipment while there is as yet no serious fire danger, and the ground can be much more quickly covered than when using matches or a stick torch.

A typical piece of gully erosion in a Chota Nagpur *sal* forest, until recently zamindari but now government property. Konar area of the Damodar Valley, Bihar.

Photo : R. M. Gorrie.



The Singrawan afforestation area showing a recently fenced but previously mutilated *sal* forest with a gully-head healed by grass and bush growth. This is the only afforestation area maintained by the Damodar Valley Corporation.

Photo : R. M. Gorrie.

INTERLOCKING OF GRAIN IN INDIAN TIMBERS

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SUMMARY

Interlocking of grain to a smaller or greater extent is a characteristic of a majority of Indian wood species. Grain has been described so far from experience of working with the timbers. An attempt has been made in this Bulletin to measure the deviation of grain and divide the species into seven groups as a step towards standardization of descriptions of wood species.

WHAT IS GRAIN ?

The term grain as used for describing the physical properties of wood concerns the direction, alignment and grouping of wood elements. The terms grain and texture are often confused. Both refer to wood elements. Texture is, however, dependent on their size and quality, which make the wood either coarse textured like *gurjun*, or fine textured like *haldu*, or smooth silky textured like boxwood, and so on. As in the case of texture, the grain is also always preceded by qualifying adjectives such as straight, spiral, interlocked, wavy, curly, uneven, etc. In this Bulletin only the first three types of grain, namely, straight grain, spiral grain and interlocked grain will be dealt with, as they affect strength and working qualities most.

STRAIGHT AND SPIRAL GRAIN

When a tree is growing, wood elements are continually being formed in the cambium just inside the bark and laid along the circumference in a vertical direction causing growth to take place both in girth and in height. When these wood elements or fibres are aligned around the circumference parallel to the vertical axis of the tree, the resulting wood is called straight grained wood. Fir, spruce and teak are examples of such woods. When the fibres are not parallel to the axis, but are laid in an inclined direction around the circumference forming a continuous spiral around the stem, the resulting wood is called spiral grained wood. The inclination may be to the right of the vertical axis or to the left causing either a right handed spiral or a left handed spiral. Spiralling is very often evident in chir (*Pinus longifolia*) and some chir forests in U.P. are very prone to this sort of behaviour. The strength of converted timber from such trees is reduced to a greater or lesser degree depending upon the angle of inclination of the fibres. Although a slight amount of spiralling is evident in many species and can be overlooked, too much spiralling causes a large deviation of grain in converted timbers and is considered a defect of wood.

INTERLOCKED GRAIN

In many Indian tree species, a reversal of spirals takes place at fairly frequent and at fairly even intervals. *Sal* (*Shorea robusta*) and *toon* (*Cedrela toona*) are good examples of this type. In such species, for some unknown reason, the successive layers of wood fibres along a radius of the trunk of a tree spiral first to the right hand and then turn slowly to the left hand to an approximately equal amount. The inclination then again slowly changes to the right hand and again to the left hand and so on, each time including a fairly even number of growth elements. Wood resulting from such type of growth, i.e., alternately reversing spirals is

called interlocked grained wood. Spiralling and interlocking seem probably hereditary characteristics and no satisfactory explanation has so far been found. Although they vary to a greater or less degree in nature in the same species and even in the same tree, the characteristic is there. Silvicultural methods have found no remedy for it so far. In some species such as *nagkesar* (*Mesua ferrea*), *anjan* (*Hardwickia binata*), *champ* (*Michelia excelsa*), *yon* (*Anogeissus acuminata*), etc., some trees are straight grained, while some others even in the same locality produce interlocked wood. It is, therefore, a problem for the Silviculturist to study such species in order to find the reason of this erratic behaviour and evolve, if possible, some suitable means of making them grow only straight grained wood. Although interlocking may not affect the strength materially (some of our very strong timbers, such as *sal* are heavily interlocked) interlocking is still a defect of timber, as such woods warp and crack in seasoning, shrink and swell considerably with changes in atmospheric moisture, do not retain their shape well and are difficult to work, peel and finish.

HOW TO DISTINGUISH INTERLOCKED GRAIN

As stated above, in the case of interlocked grain the wood fibres of successive growth laid on along a radius of the trunk are inclined to the vertical axis of the tree at different angles reaching a maximum first to one side and then to the other. If, therefore, a block of wood is split along a radial line at rightangles to the growth rings, straight grained woods will split in the same plane and will present a smooth surface and a straight radial split at the other end of the block. The wood will not offer much resistance to splitting. A block of interlocked wood will, however, offer great resistance to splitting and when split will show a wavy line at the other end instead of a clear straight line split as in the case of a straight grained timber.

Fig. 1. Top block shows split of straight grained wood. Bottom block shows typical split of heavily interlocked grained wood.

In Fig. 1, a block of fir and a block of *sal* are shown split as described above. The two left hand photographs show the radial line on the top surface along which the block is split. The two right hand photographs show the type of split surface on the bottom end. The fir block splitting straight in one plane represents a perfectly straight grained timber. The *sal* block, however, shows a wavy split at the other end representing an interlocked grained timber. A radial split in a small block of wood say 2 in. $\times$ 2 in. $\times$ 2 in. at once reveals whether the wood is interlocked.

Fig. 2 shows a large piece of *sal* split along a radial line and brings out clearly how fibres have to be torn out and why they offer considerable resistance to effecting a separation of the two parts. The split represents roughly the form of a sine curve.

Fig. 3 shows the ribbon pattern as seen on the radial surface of the block shown in Fig. 2. This is composed of alternate darker and lighter bands running along the length of the board. The difference in colour is caused by the difference in the reflecting quality of wood fibres that are inclined in opposite directions. By causing the angle of light incidence to change, it is possible to cause a reversal of the colour zones. Panels of such ribbon or stripe figure obtained by quarter sawing interlocked woods give a pleasing appearance.

MEASUREMENTS OF INTERLOCKING

The wave length CE (FIG. 4) represents the number of radial growth elements involved in a complete cycle of changes, i.e., starting from maximum inclination of fibres to one side at C slowly reversing to the maximum inclination at D to the other side and again going back to

maximum inclination at E towards the first side. The depth FD gives the amplitude of the sine curve and is a measure of the inclination of the fibres. Therefore, if the wave length CE and the amplitude FD are measured, they give a fairly accurate idea of interlocking.

For this purpose, three cubical blocks of 2 in. × 2 in. cross section and 2 in. thick are obtained from each 4 feet long test bolt One specimen is cut from sticks near the pith, one from near the periphery and the third from sticks near the middle of the cross section of the bolt. As two bolts are tested from each tree and five trees form a consignment, altogether 30 specimens of 2 in. cubes are obtained for any one consignment for the determination of interlocking characteristics. Each of the 30 specimens is then split along a radial line on one end and the resulting curve at the other end is examined. Its wave length and amplitude is carefully measured and the average for the whole species is determined. Over 7,500 specimens belonging to 270 consignments of timber were thus examined.

CLASSIFICATION OF SPECIES

Wave lengths and amplitudes of the splitting curves were then analysed and graded according to the intensity of interlocking and the species divided into several classes as given below :—

Class	Description	Average wave length inches	Average amplitude inches	No. of consignments in the group
1	Straight grained wood ..	6/16	1/16	48
2	Generally straight grained wood but has tendency to interlocking	8/16	2/16	45
3	Moderately interlocked wood	10/16	3/16	57
4	Interlocked wood ..	12/16	4/16	50
5	Heavily interlocked wood ..	15/16	6/16	45
6	Very heavily interlocked wood	19/16	8/16	9
7	Generally moderately interlocked wood, but often some trees grow straight grained	10/16	3/16	16
				270

The nature of split of the different classes of interlocking described in the above table are shown in photographs 1 to 7 in figures 5, 6, 7, 8 on the opposite pages.

Fig. 5. Split curves in blocks 1, 1 show two straight grained woods namely, fir and teak of Class 1. This shows a straight split as in fir or a very long shallow wave as in teak.

Wave length upto 6/16 in. and amplitude upto 1/16 in.

Split curves in blocks 2, 2 show two woods which are generally straight grained but have tendency to interlocking. They may have small sawtooth-like fracture as in *babul* or a shallow long wave like *semul*. They represent Class 2.

Wave length 6/16 in. to 8/16 in. and amplitude 1/16 in. to 2/16 in.

Fig. 6. Split curves in blocks 3, 3 show two woods, *bakli* and *sissoo* which also have a sawtooth-like fracture, but deeper and wider than 2, 2. They represent Class 3 namely, moderately or slightly interlocked woods.

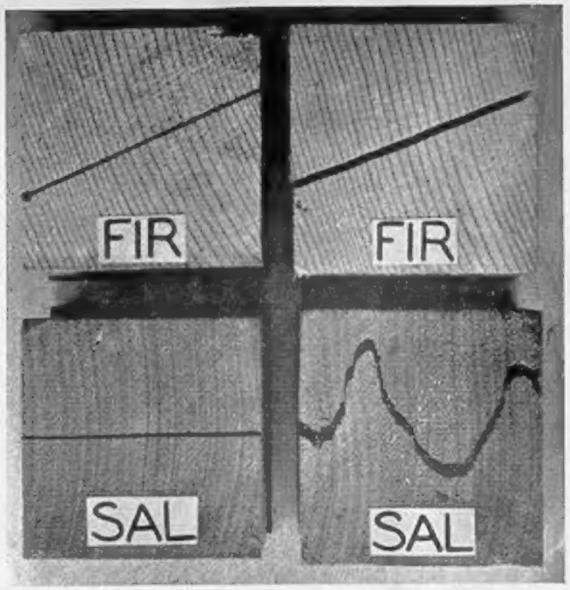

FIG. 1.

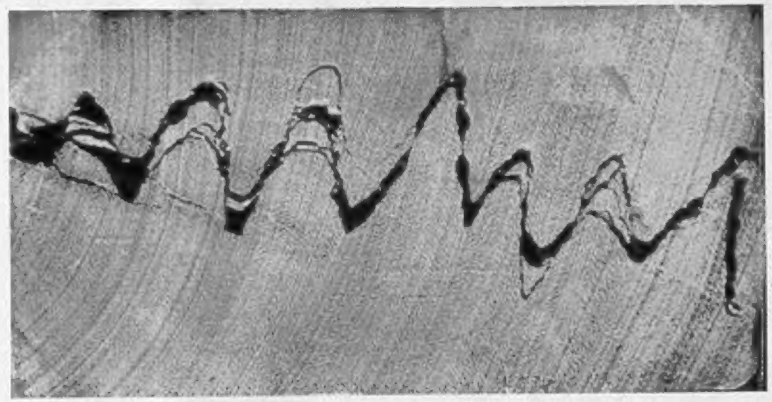

FIG. 2.

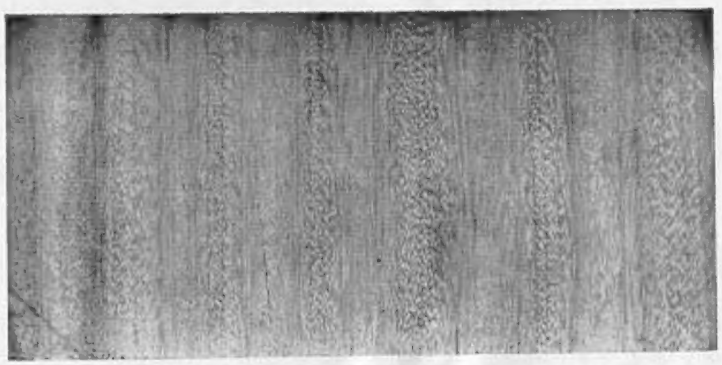

FIG. 3.

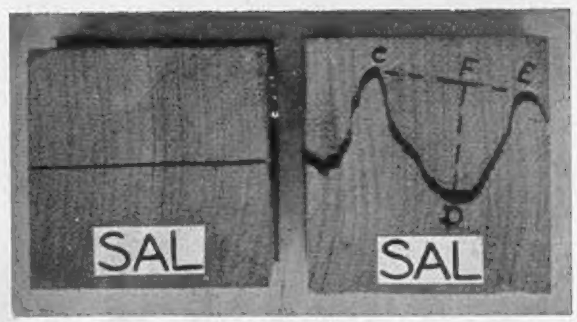

FIG. 4.

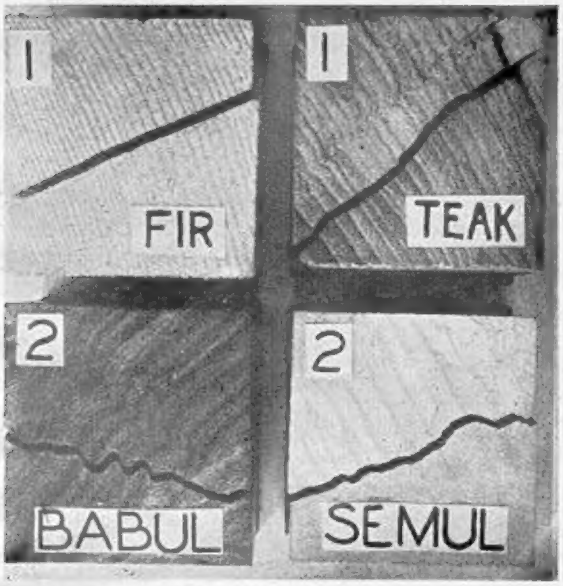

FIG. 5.

FIG. 6.

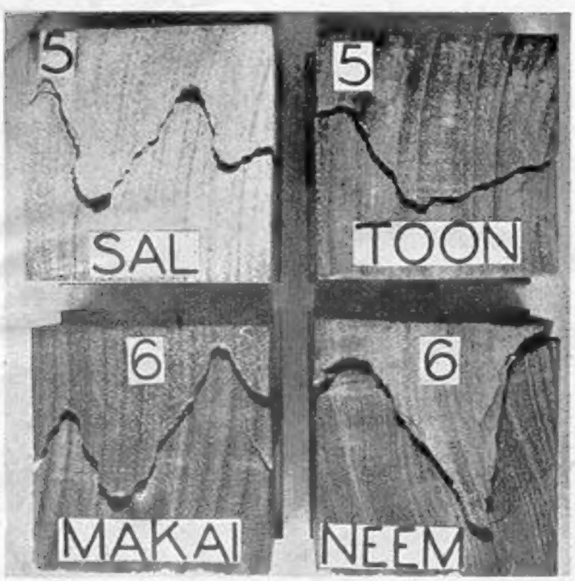

FIG. 7.

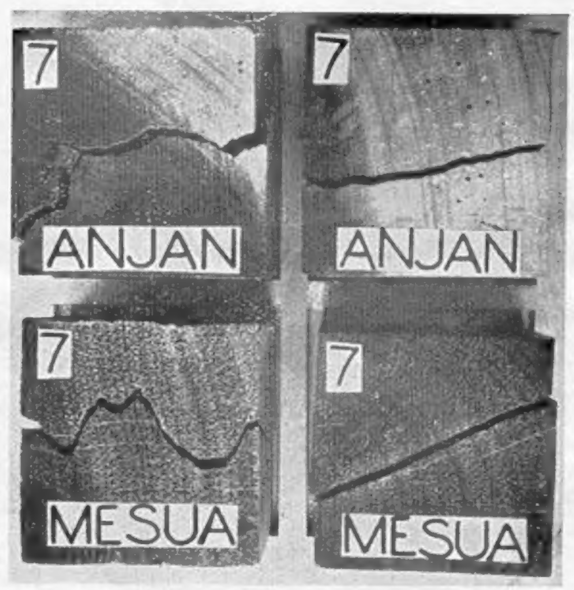

FIG. 8.

Wave length 8/16 in. to 10/16 in. and amplitude 2/16 in. to 3/16 in.

Split curves in blocks 4, 4 show two woods, *haldu* and *jaman* which represent typical interlocked fracture of Class 4. They show narrow bands of light and dark shaded wood on radial sawn planks.

Wave length from 10/16 in. to 12/16 in. and amplitude 3/16 in. to 4/16 in.

Fig. 7. Split curves in blocks, 5, 5 show two woods, *sal* and *toon*, which represent a fracture of Class 5, namely, heavily interlocked woods. They show ribbons of light and dark coloured wood as in Fig. 3 on radial cut planks.

Wave length 12/16 in. to 15/16 in. and amplitude 4/16 in. to 6/16 in.

Split curves in blocks 6, 6 show two woods, *makai* and *neem* which represent a fracture of Class 6, namely, very heavily interlocked woods. They show a very deep wave.

Wave length 15/16 in. to 19/16 in. and above amplitude 6/16 in. to 8/16 in. and above.

Fig. 8. Split curves in the two top blocks 7, 7 show two variations of grain in *anjan* wood and splits in the two bottom blocks show variations of grain in *mesua* wood. They represent Class 7 which is generally moderately interlocked grained woods but often produce straight grained trees even in the same locality. They deserve further study to find out the cause of interlocking.

As the classification depends upon two numerical measurements, sometimes difficulty may be experienced as to the class in which a particular species is to be put. For instance, in the case of (*Adina cordifolia*) *haldu*, the wave length is 14/16 and amplitude is 3/16. According to wave length it is Class 5, i.e., heavily interlocked grain, but according to amplitude it is Class 3 – moderately interlocked. It is a timber between Class 3 and Class 5. It will be in Class 4, i.e., interlocked grained wood. In such classifications border line cases will often be present and will have to be decided by individual measurements, reference to actual samples and experience of working with the timber.

THE ALL-INDIA TEAK SEED ORIGIN SAMPLE PLOTS*

BY GURDIAL SINGH MATHAUDA

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With a view to study the influence of origin of teak seed on the development of resulting plants and crops, an All-India Teak Seed Origin Co-operative Experiment was organized by the Central Silviculturist in 1930. All the teak growing provinces and Burma were asked to co-operate in the project. Bombay did not consider it necessary to join the investigation, though it readily agreed to supply the seed as required. A total of 11 seed origins† in 13 different centres‡ were tried. The investigation was sub-divided into (*a*) the short term and (*b*) the long term experiments. The object of the former was to examine the effect of seed origin in different localities during the germination, seedling and sapling stages while the latter aimed at a comparative study of the post-sapling stages. The first series of experimental plots were laid out in 1931 and new sets were added subsequently at most of the centres. The report to the 1939 Silvicultural Conference refers to Coorg and Hyderabad joining this investigation in 1938–39 and raising their nursery stocks of selected seed origins for starting properly designed experimental plots. Further information about the experiments in Hyderabad is not available. Coorg joined the long-term part of the investigation in 1939 and laid out an elaborate experimental plot at Nagarhole in 1940.

The results of the short term part of the investigation were summarized in the reports to the 1934 and 1939 Silvicultural Conferences and need not be recapitulated here. Broadly speaking, the experiments indicated "the superiority of seed of local origin to those of others in the regions of natural range of teak, as far as ease of establishment and early development, extending over a period of about 5 to 8 years are concerned.....The Nilambur origin has, however, done very well also in relatively dry zones of C.P., U.P. and Mysore". The long term experimental plots laid out in 1931–35 resulted in the formation of 7 sets of sample plots in Madras (2), Madhya Pradesh (formerly C.P.) (2), Uttar Pradesh, (2) and East Bengal (1). The object of this paper is to report on the progress made by the long-term part of the investigation since 1939.

The lay-out of the 1931 and 1933 experimental plots from which the Bengal, Madhya Pradesh and Uttar Pradesh sets originated is statistically defective because the principles of proper randomization and an adequate number of replications were ignored presumably on account of the increase in the amount of work and labour involved. Only one plot for each origin was provided, though care is reported to have been taken to select the site with as little variation in quality as possible. The data from such plots do not lend themselves to proper statistical analysis essential for a correct appraisal of the effects of the various factors involved. Only tentative guesses could be made, which may be wrong, especially where differences are small. It is only in the case of the Madras sets that the experiment was properly designed and laid out. The Nilambur set consists of 6 origins randomized and replicated

* This paper was presented before the Eighth All-India Silvicultural Conference held at Dehra Dun in December, 1951.

† (1) North Burma (Myitkyina, L. 24°N.), (2) South Burma (Tharrawady, L. 17°N.), (3) Madras, moist (Nilambur), (4) Madras, intermediate (Palghat/Walayar), (5) Madhya Pradesh, dry (Betul), (6) Uttar Pradesh, dry (Jhansi), (7) North Bombay, dry (W. Khandesh), (8) South Bombay, moist (E.D. Kanara), (9) Travancore, moist (Kottayam), (10) Mysore, moist (Kakankoti) and (11) Mysore, dry (Shimoga).

‡ (1) North Burma (Myitkyina), (2) South Burma (Zigon), (3) Madras, moist (Nilambur), (4) Madras, intermediate (Palghat), (5) Madras, intermediate (S. Coimbatore), (6) Madhya Pradesh, dry (Bilaspur on two types of soils, Schistose and Gneissic), (7) Uttar Pradesh, dry (Gorakhpur), (8) Uttar Pradesh, moist (Haldwani), (9) Travancore, moist (Koni), (10) Mysore, moist (Kakankoti), (11) Mysore, dry (Shimoga), (12) Bengal, moist (Chittagong Hill Tracts, Kaptai) and (13) Forest Research Institute, moist (New Forest).

4 times, while the South Coimbatore set has got 4 replications of 4 origins. The Coorg experimental plot, initially intended to have 6 replications of 8 seed origins, had to be modified later on, and now possesses 41 sub-plots, the number of replications varying between 7 and 1. It can yield another good set of sample plots in due course.

NILAMBUR SET

Number of Sample Plots : 24 (each about $\frac{1}{4}$ acre in area).

Origins tried—Nilambur, Anamalais, Travancore, South Bombay, South Burma, North Burma ; each with 4 replications.

Year of Plantation : 1934.

Sample plots in the Nilambur, Anamalais, Travancore, South Bombay and South Burma origins were laid out in December, 1937 and in the North Burma origin during August, 1938. The crops were fully measured at the time of formation and again in February, 1943 and May, 1949. The comparative position of each origin on these dates with regard to average diameter, average height and total volume per acre is given in the following table :—

TABLE 1.—*Comparison of different seed origins at Nilambur in 1937/38, February, 1943 and May, 1949*

Sample Plot No.	Date / Character / Seed origin	1937–38*				February, 1943				May, 1949			
		Age	Average diameter	Average height	Total volume per acre	Age	Average diameter	Average height	Total volume per acre	Age	Average diameter	Average height	Total volume per acre
1	2	3	4	5	6	7	8	9	10	11	12	13	14
		yrs.	ins.	ft.	c. ft.	yrs.	ins.	ft.	c. ft.	yrs.	ins.	ft.	c. ft.
96–99	Nilambur ..	4	2·2	21	223	9	3·7	36	714	15	5·8	51	845
100–103	Anamalais ..	4	2·1	21	212	9	3·5	33	591	15	5·3	46	776
104–107	Travancore ..	4	2·2	21	272	9	3·7	35	720	15	5·7	47	813
108–111	South Bombay ..	4	2·3	21	259	9	4·1	41	874	15	6·6	56	1088
112–115	South Burma ..	4	2·4	21	261	9	3·9	38	745	15	6·6	54	1110
116–119	North Burma ..	4	2·1	17	151	9	3·5	30	470	15	5·4	43	745

* The figures for North Burma origin pertain to the age of 5 years as these plots were laid out one year after the others.

Statistical analysis of the entire data with respect to average height, average diameter and total volume indicates the following position for the 3 dates :—

1937–38—With regard to average height the North Burma origin was significantly the poorest. The differences between the remaining five origins were not significant. The origins did not differ significantly from one another so far as average diameter and total volume were concerned.

The growth in the sub-plots of North Burma origin had been observed to be very uneven and patchy. The monkeys had been noticed to be specially fond of young terminal shoots of plants of this origin and this may have been the main cause of its poor performance.

February, 1943—On the basis of average height the South Bombay origin was significantly the best and North Burma significantly the poorest. Judged in pairs, the differences between South Burma and Nilambur, Nilambur and Travancore, Travancore and Anamalais origins were not significant, all others being so.

From the point of view of average diameter and total volume the South Bombay origin was significantly the best and the North Burma the worst.

May, 1949—With regard to average height, the inferiority of North Burma origin to all others was highly significant. The South Bombay origin was significantly superior to all the rest excepting South Burma. The latter, though not significantly different from the Nilambur origin, was superior to the remaining three. Travancore and Anamalais origins, though not different from each other, were superior to North Burma origin.

From the point of view of average diameter, the South Bombay origin was the best and the Anamalais origin the poorest. South Bombay did not differ significantly from South Burma, though both were significantly superior to the remaining four. Nilambur, was significantly superior to Anamalais, though not so to Tranvancore and North Burma. The differences between the Travancore, North Burma, and Anamalais origins were not significant.

With respect to total volume the South Burma origin was the best and North Burma the poorest. The difference between South Burma and South Bombay did not prove to be significant, though both were significantly superior to the remaining four, which, however, did not differ from each other.

It has to be pointed out that stocking per cent has varied from origin to origin and from plot to plot (e.g., in 1937/38 the stocking in the various plots was described as full, slightly open or very open : in 1943 after thinnings it varied between 56% and 88% and in 1946 after thinning between 55% and 84% of the yield table number). Height, being least influenced by spacing, is the best criterion for the purposes of comparison in this case. Judged from the point of view of height alone, it may be summarized that whereas in 1937/38 North Burma seed gave the poorest results and there was not much to choose between the remaining 5 origins, by 1949 the South Bombay and South Burma origins had established their superiority and North Burma was still the worst.

SOUTH COIMBATORE SET

Number of sample plots : 16 (each about $\frac{1}{4}$ acre in area).

Origins tried : South Burma, Mount Stuart (local), Mysore (moist), Nilambur (moist), each with 4 replications.

Year of plantation : 1934.

At the time of formation of sample plots the South Burma origin was very uneven in stocking, the Nilambur origin was less uneven and contained better trees which showed a tendency to remain longer in leaf. The Mysore and Mt. Stuart origins were better stocked than the first two. The crops were measured in February, 1939, February, 1945 and in May/November, 1949. At the time of second measurement, sample trees of larger diameter had not been measured. It has, therefore, not been possible to compute the volume figures for 8 out of the 16 sample plots for this age. Again, whereas 12 of the sample plots were measured in May, 1949, this operation was postponed till November, 1949, in the case of the remaining 4.

This defect does not permit direct comparison for this date. The crop heights of the above mentioned 4 plots in May, 1949, have been deduced from yield tables and used for purposes of comparison. The position of the various origins before thinnings in February, 1939, February, 1945 and May, 1949 and the results of statistical analysis are summarized in Table 2 and the subsequent remarks :—

TABLE 2.—*Showing the position of various origins at South Coimbatore up to May, 1949*

Sample Plot No.	Date	February, 1939				February, 1945			May, 1949	
	Character / Seed origin	Age	Average height	Average diameter	Total volume per acre	Age	Average height	Average diameter	Age	Average height
1	2	3	4	5	6	7	8	9	10	11
		yrs.	ft.	ins.	c. ft.	yrs.	ft.	ins.	yrs.	ft.
2, 9, 13, 14	South Burma ..	5	20	2·5	289	11	33	4·7	15	41
3, 8, 12, 15	Mount Stuart ..	5	26	3·1	666	11	43	5·8	15	53
4, 7, 11, 16	Mysore ..	5	23	2·9	480	11	41	5·4	15	50
5, 6, 10, 17	Nilambur ..	5	24	2·9	496	11	41	5·5	15	51

February, 1939—With regard to average height, Mt. Stuart origin is significantly superior and South Burma origin significantly inferior to all, Nilambur and Mysore origins not being significantly different from each other. With respect to average diameter and total volume, South Burma is significantly inferior to the first three, which, however, do not differ from each other significantly.

February, 1945—With regard to both average height and average diameter the South Burma origin was significantly inferior to the remaining three, which did not differ significantly from each other. The plots of South Burma origin were still very unevenly stocked.

May, 1949—The above position has remained unaltered with regard to average height.

Thus, it is obvious that up to 1949 the South Burma origin has given the worst results in South Coimbatore division and there is not much to choose between the remaining three seed origins.

MADHYA PRADESH (BILASPUR) SETS

Number of sample plots : 12 (each about $\frac{1}{4}$ acre in area).

Year of plantation : 1931.

Two sets of 6 sample plots each, were formed in May, 1938 on (*a*) Gneissic soil and (*b*) Schistose soil, the seed origins involved in both the sets being Tenduchula (Madhya Pradesh), Mysore (moist), Bombay (moist), Betul (Madhya Pradesh), Nilambur (moist), and North Burma.

Ignoring the soil differences there are two replications of 6 origins and if differences due to seed origins were over-looked there are 6 replications of each soil type. The replications for the origins are not adequate for clearly bringing out the influence of this factor.

According to the report submitted to the 1939 Silvicultural Conference the Gneiss set was considered to have done better than the other one from the point of view of both stocking

and growth. Out of the various origins, Nilambur was considered to be the best, Mysore the second best and Betul the the worst. There is no evidence that these conclusions were based on strict statistical analysis : it appears more likely that, as in the case of the U.P. and Bengal sets, they resulted from superficial examination and the differences may not be statistically significant.

The 1939 thinnings were 'free' in the Gneiss set and 'ordinary crown' in the Schist set. The stocking per cent in the former was uniformly higher than in the latter. This lack of uniformity in the type and intensity of thinning is likely to frustrate the very object of the experiment, as the influence of seed origin cannot be determined if the crops are not uniformly treated in respect to other factors. Accordingly, this defect was set right at the time of the next thinnings in May, 1943 when all the plots were thinned to the same intensity. The uniformity in thinning treatment has been again upset at the time of the last full measurements in June, 1950 when the local authorities, overlooking the original object of the investigation and the objections raised in 1939, converted the plots into a thinning research experiment, the stocking varying from 64% to 124% of the yield table figures.

As the stocking in the plots has not been uniform a comparison between the various origins based on diameters or volumes would be misleading. This is, therefore, attempted only on the basis of heights. The actual position of the various origins on the two types of soils in January, 1939, May, 1943, and July, 1950 is illustrated by the following table :—

TABLE 3.—*Showing the comparative performance of different seed origins at Bilaspur up to July, 1950*

Sample Plot No.	Date / Character / Set / Seed origin	January, 1939			May, 1943			July, 1950		
		Age (yrs.)	Average height (ft.)		Age (yrs.)	Average height (ft.)		Age (yrs.)	Top height (ft.)	
			Gneiss	Schist		Gneiss	Schist		Gneiss	Schist
1	2	3	4	5	6	7	8	9	10	11
9, 15	Tenduchula ..	8	34	34	12	44	41	19	64	61
10, 16	Mysore ..	8	34	32	12	44	41	19	63	63
11, 17	Bombay (Kanara)	8	29	30	12	37	37	19	62	58
12, 18	Nilambur ..	8	35	29	12	46	43	19	65	64
13, 19	Betul ..	8	31	38	12	41	50	19	63	68
14, 20	North Burma ..	8	29	29	12	39	39	19	59	60
	TOTAL ..	..	192	192	..	251	251	..	376	374
	MEAN ..	..	32	32	..	42	42	..	63	62

Statistical analysis for both the sets taken together has given following results :—

January, 1939—The height growth on the two soil types was practically the same. The differences due to seed origins were, however, significant, the order of superiority between the various origins being: Nilambur, Tenduchula, Mysore, Betul, Bombay and North Burma.

Nilambur was significantly superior to all, the differences between Tenduchula, Mysore and Betul or between Mysore, Betul and Bombay or between Betul, Bombay and North Burma being not significant.

May, 1943—The origins in order of superiority were Nilambur, Tenduchula, Mysore, Betul, North Burma and Bombay. There was no significant difference either due to soils or origins.

July, 1950—The order of merit was: Nilambur, Betul, Mysore, Tenduchula, Bombay and North Burma. As during 1943, the differences due to soil or seed origins have not proved to be significant.

Whereas the 1943 and 1950 differences due to soil types have been small, those due to origins are considerable, and have probably remained masked for want of an adequate number of replications. It appears, that up to this stage, the Nilambur origin is probably the best and the North Burma and Bombay origins the worst. There is not much to choose between Betul, Tenduchula and Mysore.

HALDWANI SET

Number of sample plots: 5 (each about ¼ acre in area).

Year of plantation: 1931.

Seed origins tried: North Burma, South Burma, Nilambur (moist), North Bombay (dry) and South Bombay (moist).

Due to frost damage the whole plantation was cut back in March, 1934 and a varying large proportion yet again cut back after the frost early in 1935. The North Bombay plot was specially affected and in 1936/37 it did not look as if it could develop as a close-canopied crop at all. Sample plots in all the origins were laid out in January, 1939. Since 1943 the crops have been thinned to practically the same intensity, so that they have grown under more or less comparable conditions. The position regarding height, average diameter and stocking % after thinning in January, 1939, March, 1943 and April, 1948 has been summarized in the following table :—

TABLE 4.—*Comparison of the performances of different seed origins at Haldwani up to April, 1948*

Sample Plot No.	Date / Character / Seed origin	January, 1939				March, 1943				April, 1948			
		Age	Average height	Average diameter	Stock-ing	Age	Top height	Crop diameter	Stock-ing	Age	Top height	Crop diame er	Stock-ing
1	2	3	4	5	6	7	8	9	10	11	12	13	14
		yrs.	ft.	ins.	%	yrs.	ft.	ins.	%	yrs.	ft.	ins.	%
47	North Burma ..	8	34	3·9	57	12	53	6·4	94	17	66	8·5	93
48	South Burma ..	8	38	4·2	70	12	54	6·8	94	17	66	9·0	93
49	Madras (moist) ..	8	36	3·9	70	12	53	6·3	94	17	66	8·8	90
50	North Bombay (dry) ..	8	35	3·4	69	12	48	5·1	93	17	60	7·0	91
51	South Bombay (moist) ..	8	40	4·3	70	12	54	6·5	95	17	67	8·8	95

Although it is not possible to test the differences between the various seed origins statistically, a glance at the 1943 and 1948 figures shows that North Bombay origin has produced distinctly inferior results and the differences between the remaining 4 origins are very slight. Thus, it appears that the seed from dry regions of North Bombay does not suit the moist climate of Haldwani.

GORAKHPUR SET

Number of sample plots: 6 (each about ¼ acre in area).

Year of plantation: 1931.

Six seed origins – North Burma, South Burma, Nilambur, North Bombay (dry), South Bombay (moist) and Madhya Pradesh (dry) – were tried with only one replication of each. At the time of formation of sample plots in 1937, the Nilambur and South Bombay origins were considered to be the best, Madhya Pradesh and North Burma the 2nd best, and South Burma the worst. Full measurements, combined with thinnings, were carried out during January, 1940, February, 1945 and February, 1950, when the crops were 9, 14 and 19 years old. Since 1940 the plots have been thinned to the same intensity, so that they have developed under comparable conditions of growth. The position of the various origins with regard to top height, average diameter and stocking % after thinnings in January, 1940, February, 1945 and February, 1950, is illustrated by the following statement :—

TABLE 5.—*Comparison of the performances of different seed origins at Gorakhpur up to February, 1950*

Sample Plot No.	Date / Character / Seed origin	January, 1940				February, 1945				February, 1950			
		Age	Top height	Average diameter	Stocking	Age	Top height	Average diameter	Stocking	Age	Top height	Average diameter	Stocking
1	2	3	4	5	6	7	8	9	10	11	12	13	14
		yrs.	ft.	ins.	%	yrs.	ft.	ins.	%	yrs.	ft.	ins.	%
32	North Burma ..	9	51	5·1	100	14	58	6·4	96	19	66	8·3	95
33	South Burma ..	9	48	4·5	101	14	57	6·2	97	19	67	7·9	93
34	Nilambur ..	9	52	5·1	100	14	58	6·3	95	19	67	8·6	99
35	North Bombay ..	9	44	4·2	101	14	50	5·5	95	19	57	6·9	97
36	South Bombay ..	9	51	5·3	101	14	55	6·5	95	19	60	7·8	100
37	Betul (M.P.) ..	9	49	4·8	101	14	58	6·1	96	19	65	7·3	96

Thus it appears that North Bombay (dry) origin is the worst and South Bombay and Madhya Pradesh origins also are distinctly inferior to the remaining 3 out of which the choice is difficult though Nilambur seems to have been steadily gaining on North and South Burma origins.

BENGAL SET (CHITTAGONG HILL TRACTS)

Number of sample plots : 6 (each about ½ acre in area).

Year of plantation : 1933.

Six seed origins – i.e., North Burma, Nilambur (moist), South Burma, Local, North Bombay (dry) and South Bombay (moist) – were tried and sample plots laid out during 1938 and 1941. In 1938/39 the Nilambur origin was considered to be the best, North and South Burma origins second best and North Bombay the worst. These plots now lie in East Pakistan, and information after 1947 is not available. Full measurements had been carried out during March/April, 1941 and February, 1947 when the crops were 8 and 14 years old respectively. Information regarding top height and average diameter for the various origins in 1941 and 1947 is given in the following table :—

TABLE 6.—*Comparison of the performances of different seed origins in Chittagong Hills up to February, 1947*

Sample Plot No.	Date / Character / Seed origin	March/April, 1941			February, 1947		
		Age	Top height	Average diameter	Age	Top height	Average diameter
		yrs.	ft.	ins.	yrs.	ft.	ins.
26	South Burma ..	8	55	5·3	14	80	7·6
27	Nilambur ..	8	57	5·1	14	74	7·4
28	North Burma ..	8	54	5·2	14	72	7·5
29	Local (Kaptai) ..	8	53	5·0	14	73	7·4
32	North Bombay ..	8	55	4·8	14	77	7·0
33	South Bombay ..	8	51	4·7	14	70	7·0

Up to the age of 14 years the South Bombay origin appears to be the worst and South Burma the best both from the point of top height as well as average diameter. The differences between South Burma and North Bombay origins on the one hand and between South Burma, North Burma, local and Nilambur origins on the other, are very small.

THE COORG EXPERIMENTAL PLOT

An area of 24 acres was split up into 48 sub-plots of half acre each. Eight seed origins – Nilambur (Madras), South Bombay, Madhya Pradesh (Betul), Mount Stuart (Madras), South Burma, North Burma, Coorg and Mysore were to be tried and each was to have 6 replications. Equal quantities (80 pounds) of seed of each origin were sown under comparable conditions in a special unirrigated nursery at Nagarhole during 1939. Germination of seed and development of seedlings turned out to be very unsatisfactory in the case of Madhya Pradesh and North Burma origins. All the sub-plots allotted to the remaining six seed origins were planted up with root and shoot cuttings in April, 1940. Only 380 and 120 satisfactory stumps respectively could be obtained for the former two origins at this time

and were utilized to stock part of a sub-plot in each case. The work done in April, 1940 and the condition of planting stock utilized was as below :—

TABLE 7.—*Work done in April, 1940 and the condition of planting stock used*

Seed origin	Number of sub-plots planted	Number of stumps used	Size of stumps used		
			Maximum	Minimum	Average
			in.	in.	in.
Nilambur	6	600 × 6	0·8	0·4	0·6
South Bombay ..	6	Do.	0·8	0·4	0·5
Madhya Pradesh	1	380	0·5	0·3	0·4
Mount Stuart ..	6	600 × 6	0·8	0·4	0·6
South Burma ..	6	Do.	0·8	0·4	0·6
North Burma	1	122	..	..	..
Coorg	6	600 × 6	0·9	0·4	0·6
Mysore	6	Do.	0·9	0·4	0·6

Some of the sub-plots allotted to Madhya Pradesh and North Burma origins were planted up as suitable stock became available in the next two years. Others were left blank and two of these were planted up with Nilambur and Coorg origin stocks in 1942. The original design thus came to be modified. Ultimately it was possible to have only 41 fully stocked sub-plots – 7 each for Nilambur and Coorg origins, 6 each for South Bombay, Mount Stuart, South Burma and Mysore origins, 2 for North Burma origin and 1 for Madhya Pradesh origin. Casualties in all the plots were replaced in the year of planting. They were markedly high in Madhya Pradesh and North Burma plots and had to be beaten up repeatedly till, by the end of 1941, they were on par with the others from the point of view of survival per cent. The experiment has been maintained to date. Detailed records of 100 plants selected in a systematic manner from each plot have been kept. These were measured annually for heights till 1945 and after that for diameters at breast height till May, 1949.

Leaving aside the 2 sub-plots planted with Nilambur and Coorg stock in 1942, the comparative position of the eight origins in April, 1943 and March, 1945 is shown in Table 8.

TABLE 8.—*Position of the different origins in April, 1943 and March, 1945*

Seed origin	Number of sub-plots	Survival per cent		Mean height in feet	
		April, 1943	March, 1945	April, 1943	March, 1945
Nilambur	6	89	90	8·2	10·8
South Bombay ..	6	96	95	10·1	13·4
Madhya Pradesh ..	1	50	41	3·1	4·6
Mount Stuart ..	6	97	93	9·2	12·4
South Burma ..	6	96	91	9·2	11·4
North Burma ..	2	41	45	1·2	2·5
Coorg	6	93	91	8·4	10·6
Mysore	6	95	91	8·8	10·5

PHOTO 1.—Crop of Nilambur origin in S.P. 30, Coorg. Age 12 years, top height 36′, crop dia. 4·7″.

PHOTO 2.—Crop. of South Bombay origin in S.P. 38, Coorg. Age 12 years, top height 38′, crop dia. 4·5″.

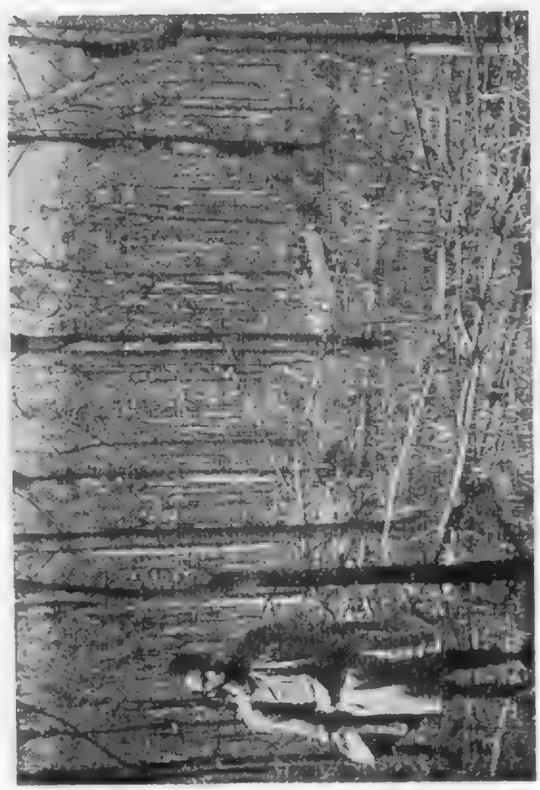

PHOTO 3.—Crop of Mount Stuart origin in S.P. 47, Coorg. Age 12 years, top height 25′, crop dia. 3·3″.

PHOTO 4.—Crop of South Burma origin in S.P. 40, Coorg. Age 12 years, top height 25', crop dia. 3·4". Most of the trees have badly scarred boles and bushy crowns.

PHOTO 5.—Portion of stem and branches of a tree of South Burma origin showing the injury to the bole resulting probably from the activities of some *Indarbelid* larvae and termites and gall formation on the branches caused by some *Itonidid* insect.

PHOTO 6.—Crop of local origin in S.P. 36, Coorg. Age 12 years, top height 35', crop dia. 4·3".

PHOTO 7
Crop of Mysore origin in S.P. 54, Coorg. Age 12 years, top height 31′, crop dia. 3.9″.

PHOTO 8
Crop of North Burma origin in S.P. 34, Coorg. Age 11 years, top height 33′, crop dia. 4.1″.

The Madhya Pradesh and North Burma origins were thus very much inferior to the remaining six both on the basis of survival per cent and mean height. The differences in survivals are statistically significant. As the crops of the former two origins were younger in age than those of other origins, statistical tests of significance for differences in mean height are not justified. It is, however, obvious that a difference of one year in age could not possibly account for the marked inferiority in height. The performances of the remaining 6 origins, both from the point of view of survivals and heights are mutually comparable.

The position in May, 1949 has been carefully examined through the kind co-operation of the Statistician, Forest Research Institute. The Madhya Pradesh and North Burma

origins which had been planted in 1941 have been excluded from analysis on that account and the results are summarized in the following statement.

TABLE 9.—*Position of different seed origins from the point of view of survival per cent and diameters in May, 1949*

Seed origin	Nilambur (A)	Bombay (B)	Mount Stuart (D)	South Burma (E)	Coorg (G)	Mysore (H)	Significance	Bar diagram at 5% level
No. of plots planted	6	6	6	6	6	6	..	..
No. of trees measured in each plot ..	100	100	100	100	100	100	..	..
Survival %	86	88	81	75	82	78	†	BAGDHE
Mean diameter at b.h. ± S.E. in inches ..	3·30 ± 0·112	3·42 ± 0·112	3·23 ± 0·112	2·93 ± 0·112	3·13 ± 0·112	2·92 ± 0·112	*	BADGEH

* Significant at 5% level of probability. † Significant at 1% level of probability.

The results obtained indicate that the above differences in seed origin have given rise to significant differences in survival per cents and mean diameters of the resulting teak crops. Bombay and Nilambur origins have given significantly better performance than Mysore and South Burma origins. It may also be stated that the values of survivals and mean diameters for the Madhya Pradesh and North Burma origin plots were 49 and 52 per cent and 2·1 and 2·5 inches respectively. They were, thus, much inferior to the poorest of the remaining six seed origins.

It was intended to lay out the required set of sample plots in this experimental plot during 1945–46. This unfortunately has not been done. The crop is 12 growing seasons old now and the first thinnings have already been delayed by about 6 years. One sample plot in each sub-plot should be formed and thinnings carried out without further delay*. This will give us 41 sample plots for 8 seed origins and, leaving out the Madhya Pradesh and North Burma origins with 3 plots, we shall have 38 plots for 6 origins, i.e., 6–7 replications in each case which is the best that we have so far got under this investigation.

From the above account it appears that it is difficult to predict the behaviour of teak crops from different seed origins in any locality. The matter has to be investigated for each place independently. Also, as the comparative behaviour of crop from the same origin may vary with age, this investigation should be carried out over the full rotation. *The experience so far gained indicates that, generally, in the regions of natural range of teak, the local seed is likely to give good results but may not prove to be the best. Of the imported seed, that from dry localities, is not usually so good as that from the moister areas.*

* This work was subsequently done in February, 1952 when 37 sample plots – 6 each for Nilambur, South Bombay, Mount Stuart, South Burma, Coorg and Mysore origins and one for North Burma origin – were laid out and a 'D' grade thinning carried out in each case. The condition of the crops of these origins is illustrated by photos 1 to 8. Two sub-plots, originating from Madhya Pradesh and North Burma stock, being practically blank, had to be discarded. It was also not considered necessary to start sample plots in the two sub-plots planted with Nilambur and Coorg stock in 1942 as these origins had already got their normal quota of 6 sample plots each.

Examination of the crops of various origins in the field revealed that the South Burma teak has not done well in this locality. The trees in this case have excessively branchy crowns and badly scarred and gnarled stems with very low potential timber value. The primary injury to the stem is caused by some *Indarbelid* larvae feeding in the cambial layers. The termites later on start their depredations via the dead tissues so exposed. The growing branches are repeatedly killed back giving the plants a characteristic bushy look. The crowns can further be distinguished by the presence of numerous gall formations mainly at the extremities of the branches which are present in crops of other origins to a very limited extent only. It is clear that teak of South Burma origin can not yield good timber under the Coorg conditions. The real competition now lies between the remaining five seed origins, i.e., Nilambur, South Bombay, Mount Stuart, Coorg and Mysore.

The above conclusions, however, are based on the size of trees and volume production alone. The quality of timber produced, i.e., its weight and strength properties, freedom from knots, and presence or absence of figure – is equally, if not more, important. It is, therefore, suggested that samples of timber from each origin should be examined at the Forest Research Institute and detailed field observations about the bole form, branchiness, etc., of trees from the various origins recorded at the time of each measurement.

The necessity of a consistent thinning policy for the investigation is obvious, as no comparisons about the relative performance of the various origins are possible unless all the plots in the set have received comparable thinning treatment in the past. The subject has been dealt, vide Appendix II of the report to the 1939 Silvicultural Conference (item No. 4). Thinnings in these plots were divided into two parts : (*a*) early thinnings up to the time the most backward plot in the set attained a top height of about 50 feet and (*b*) later thinnings. The early thinnings aim at eliminating the irregularities due to variation in initial stocking and thus giving all the plots a comparable start. It was suggested that they should be based on the yield table number – top height – age relationship. The object of the later thinnings is to allow the various origins to develop according to their inherent aptitudes by altering the thinning cycle, and keeping the thinning grade constant. The following procedure was suggested to achieve this aim :—

"After the initial period of thinning according to height and age is over, and regularity in stocking has been achieved, an arbitrary set of thinning intervals such as would be considered suitable for an average crop in that locality will be laid down (e.g., at ages 25, 40 and 60 or some such series, depending on the rate of growth and the rotation). The yield table will then be consulted, and for the fractional quality of each plot, the final crop basal area will be determined at each of the above ages. Owing, however, to hereditary variations it is expected that diameter increment will be different in different origins. It is prescribed, therefore, that the different origins will be thinned as soon as their basal area per acre reaches the figure determined in the manner described above. Thus rapidly growing origins will be thinned earlier and slower growing origins later than the arbitrary cycle laid down".

The above procedure is too complicated and is bound to give rise to serious practical difficulties especially in the case of the elaborate sets of sample plots in Madras and Coorg. It will amount the to measurement of the various plots due for thinning almost annually in order to find out which of them could be actually thinned during that particular year. Moreover, as the yield tables do not give basal area figures for grades of thinning other than "C", all the plots will have to be thinned to this grade, which now is generally regarded to be too light for the species. It is felt that the same object can be more easily achieved by adhering to the same thinning cycle in all the cases and carrying out the thinning operation on the basis of the yield table N/D relationship for the particular fractional quality. As the number of stems to be retained would depend on both the height and diameter growth in each case, this procedure, in addition to being simple, would give ample opportunities to each seed origin to develop according to its inherent trend. It would also be possible to thin crops to any intensity by varying the ratio of the number of stems retained to that determined from the yield tables.

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GRASSES OF THE UPPER GANGETIC PLAIN AND SOME ASPECTS OF THEIR ECOLOGY

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ABSTRACT

This work deals with the grasses of 'The Upper Gangetic Plain', covering an area of approximately 196,000 square miles, namely the states of Uttar Pradesh, Delhi, Ajmer-Merwara, East Rajasthan, Vindhya Pradesh and Madhya Bharat (Places above 2,300 ft. have been excluded). After discussing some aspects of ecology and the evolution of the grasses, forest and grassland climates, indicator value of grasses, grazing problems and improvement of fodder supplies, two hundred and fifty species belonging to about one hundred genera found in the area have been enumerated.

Since considerable nomenclatural confusion exists in the *Gramineae*, efforts have been made to follow the rules of nomenclature and to adopt the most recent names as far as practicable.

Three new names, viz., *Erianthus procerum* (Roxb.) Raizada, *Themeda longispatha* (Hack.) Raizada et Jain and *Cymbopogon stracheyi* (Hk. f.) Raizada et Jain have been proposed.

The present work is based chiefly on the material deposited in the Dehra Dun Herbarium and is the first consolidated account of the *Gramineae* of 'The Upper Gangetic Plain, and of the adjacent Siwalik and the Sub-Himalayan tracts'.

PREFACE

The 'Flora of the Upper Gangetic Plain' (*Ranunculaceae* to *Juncaceae*) was published by Mr. J. F. Duthie in parts from 1903–1920. The families *Palmae* to *Aroideae* and *Alismaceae* were also completed (in MSS) by him before his death in 1922. These and the rest of the families up to the *Cyperaceae* were published by Messrs. Parker and Turrill in 1929. Mr. Duthie had also made exhaustive collections of the grasses of this area and had published in 1883 the 'Grasses of North-Western India' and in 1888 the 'Fodder Grasses of Northern India'. The former is merely a list of the grasses and the latter too lacs detailed descriptions. Since that time the *Gramineae* of the Upper Gangetic Plain received no particular attention. The sole work available on Indian grasses is the seventh volume of Hooker's Flora of British India which was published in the year 1896. Since Hooker's time the systematy of the *Gramineae* has received considerable attention from agrostologists, particularly in Europe. The modern tendency has been towards smaller and better defined groups, so that the genera of Hackel and Hooker, with their multiplicity of species, have to a large extent disappeared and their place has been mainly taken by the sections of the larger genera which now receive full generic rank. The strict application of the International Code of Botanical Nomenclature has resulted in the elimination of certain specific names which have stood firm for half a century or more. A clearer conception of the affinities and floral structure of certain grasses has caused the transference of a species from one genus to another, or even the creation of a new genus. In view of this, the publication of an account of the grasses of the Upper Gangetic Plain was considered all the more desirable.

Dr. Bor in 1941 published an account of some 'Common grasses of the United Provinces'. Much confusion in the nomenclature of the grasses of this area has been eliminated in this work, but this treatize embodies only 92 grasses from Uttar Pradesh, which is less than half the number recorded here. The area of Uttar Pradesh is only half the area of Upper Gangetic Plain as taken by Duthie. The area covered by Duthie and adopted in the present work covers approximately 196,000 square miles covering the present Uttar Pradesh, Delhi, Ajmer-Marwara, East Rajasthan, Vindhya Pradesh, Bhopal, Madhya Bharat and Northern part of the state of Madhya Pradesh (Saugor district). The area includes only the plains and sub-montane tracts of Garhwal and Kumaon, up to 2,300 ft. elevation.

The present study was started by the writer in January 1950 in collaboration with Messrs. S. K. Jain and R. C. Bharadwaja, trainees in Systematic Botany and Taxonomy, and is based chiefly on the material deposited in the Dehra Dun Herbarium, over a period of 75 years, by various collectors, viz., Duthie, Inayat, Gamble, Hole, Champion, Osmaston, Lowrie, Sri Ram, Gupta, Sen and the author.

Modern nomenclature has been adopted here as far as practicable and where changes have occurred the synonym as it appears in Hooker's Flora of British India is given. Nobody regrets more than botanists do, the necessity for changing old established names in accordance with the rules of priority, but the sooner all necessary changes are made the sooner will stability be reached.

In accordance with the more recent views of Pilger and Jesweit, *Saccharum* and *Erianthus* have been treated as separate genera, consequently the grasses generally referred to as *Saccharum munja* Roxb., *S. arundinacea* Retz. and *S. procerum* Roxb. have been described as *Erianthus munja* (Roxb.) Jesw., *E. arundinaceus* (Retz.) Jesw. and *E. procerus* (Roxb.) Raizada respectively. Similarly in accordance with Bor's view *S. narenga* Wall. becomes *Narenga porphyrocoma* (Hance) Bor.

In many cases Henrard's recent findings have been followed and many of the names proposed by him have been accepted :—*Arthraxon quartinianus* Nash for the grass generally referred as *A. hispidus* (Thunb.) Makino, or *A. ciliaris* Beauv. ; *Eulalia trispicata* Henr. for *E. tristachya* Ktze. ; *Digitaria adscendens* Henr. for the Indian material under *D. sanguinale* Scop., *D. marginata* Link., or *Paspalum sanguinale* Link. ; *Digitaria corymbosa* (Roxb.) Merrill for *Paspalum sanguinale* var. *extensum* Hook. f. ; and *Digitaria cruciata* (Nees) Camus for *P. sanguinale* var. *cruciatum* Hook. f.

The 'Sabai' grass, a plant of great economic importance, has unfortunately been referred to in the past by more than half a dozen different names, such as *Ischaemum angustifolium* Hack., *Pollinidium angustifolium* Haines, *P. binatum* C. E. Hubb., etc. It is now correctly called *Eulaliopsis binata* (Retz.) C. E. Hubb.

Themeda gigantea subsp. *avenacea* var. *longispatha* Hack. and *Andropogon nardus* var. *stracheyi* Hook. f. have been regarded distinct enough to be raised to specific rank, and are named *Themeda longispatha* (Hack.) Raizada and Jain, and *Cymbopogon stracheyi* (Hook. f.) Raizada and Jain, respectively.

Eremopogon strictus Camus has been regarded as distinct from *E. foveolatus* Stapf, and our grass from this area falls under the former name. *Dichanthium aristatum* (Poir.) C. E. Hubb. (*Andropogon caricosus* var. *mollicomus* Hack. f.), a grass often regarded identical with *D. caricosus* Camus has been kept as a separate species.

Rhynchelytrum repens C. E. Hubb. (Natal Grass), a native of Africa and reputed as a good fodder, has become naturalized in Assam. It was successfully grown at Dehra Dun and has been included.

Thaumastochloa cochinchinensis (Lour.) C. E. Hubb. has recently been collected by the author from Dehra Dun. An earlier collection of this grass was made in the 19th century by Kurz and Mokim from Rajmahal Hills, Bihar. In Indian Floras it has been described only in Haines' Botany of Bihar and Orissa under its invalid name *Ophiurus monostachyus* Presl.

An account of the grasses together with notes on some aspects of their ecology, occurring in the area has been drawn and is being published here in the first instance. It may not be possible to publish the entire detailed work in one volume and at one time, and it is hoped, therefore, that this consolidated account will serve a useful purpose. The list contains about one hundred genera and two hundred and fifty species. Reference to Hooker's Flora of British India Vol. 7 has been given in each case.

I am greatly indebted to Dr. N. L. Bor, Assistant Director, Royal Botanic Gardens, Kew, for his ready assistance in advising me on many nomenclatural complications and on critical specimens.

INTRODUCTION

The value of grass to mankind has been recognized since very early times and the culture of cereal grasses dates back to a period when men was emerging from the wild-beast stage. One need only mention wheat, rice, oats, maize, barley, millet, all of them cultivated grasses, to convince anyone of the immense value of grass in the economy of nations. Man, by careful selection and culture, has improved enormously upon the raw material which Nature placed at his disposal, with the result that the cultivated grasses of to-day bear little resemblance to their wild ancestors.

Although Man has cultivated cereal grasses for a very long period, it was not until comparatively recent times that he has turned his attention to the improvement of pasture grasses by the scientific methods of plant breeding. A very great deal of valuable work has been carried out in Europe on the pasture grasses and encouraging results have been obtained. European and American systematists, too, have contributed largely to a better understanding of what is usually considered to be a difficult group of plants.

Efforts in India, in so far as the pasture grasses are concerned, have been confined to the improvement of existing grassland and the introduction of suitable exotic species.

Little work has been done on Indian *Gramineae* since J. D. Hooker brought the Flora of British India to a close in 1897 with a volume on grasses, in spite of the fact that India possesses a grass flora which for richness bears comparison with any other area of comparable size in the whole world. This richness, or "exuberance of species" as Hooker would have termed it, is due to the vast range of climates, habitats and exposures which are found within the confines of the Indian Peninsula. In India it is still the custom, even in scientific publications, to give the species of grasses the names of the Flora of British India, in spite of the fact that German, French, English and American agrostologists recognize entirely different names. As long as these publications are meant for a limited circle only, this is quite all right, but it will be conceded that the results of research should be available to as wide a circle of readers as possible, and it is very desirable that the scientific names of grasses used are those which are understood in circles abreast of current thought and research.

GENERAL ECOLOGY AND THE EVOLUTION OF THE GRASSES

In order to be able to understand grasses and grassland it is necessary to know something regarding the evolution of the species of the family.

It is generally agreed amongst botanists that, of the *Gramineae*, the *Bambuseae* are the most primitive. Following in order come the remainder of the *Pooideae* and the *Panicoideae*. Apart from morphological grounds the natural habitats of the grasses themselves support this theory.

That the environment determines the destiny of the species is a truism that will not be disputed by anybody who gives the most cursory thought to the subject. Of all the factors which go to make up the environment the most important are moisture and temperature and of these two, moisture (whether in the form of precipitation or soil moisture) plays the more important role.

As regards these two factors there are very good grounds for believing that, about the time when higher plant life began to develop upon the earth, conditions were far more favourable than they are to-day. The deposits of coal in many widely separated parts of the earth, the result of the luxuriance of vegetation of the Carboniferous Age, suggest that the climate of those times was less influenced by the changes of the seasons than it is to-day and was in fact more or less uniform over the surface of the earth. In other words, it is more than probable that the present day vegetation had its origin in a climate characterized by high temperatures, great aerial humidity and heavy precipitation.

As time went on and seasons and climate became differentiated, new habitats and environments, which made more and more exacting demands upon species for their existence, came into being. It may be assumed that advance took place primarily in response to changing conditions of temperature and water-supply.

However, species arose, and this is not the place for the discussion of any particular theory of the origin of species ; those that were better adapted to the new conditions came to occupy the environments that were best suited to them.

Of all the habitats in the world at the present time that which has changed the least is the tropical forest. Within the forest the factors of temperature and aerial humidity are less liable to the violent fluctuations that are experienced in the open and in addition there is always an abundant supply of moisture in the soil.

It would be expected that the most primitive grasses of all would be found in the oldest and most unchanging habitat, the tropical forest. To this may be added the moister habitats in the tropics ; the marshes, river banks and bils. If these habitats are considered as a closely allied whole then they define the natural home of nearly all the *Pooideae*. This statement is not absolutely true of course, because many *Andropogoneae* are to be found within the forest or along its margins, while primitive grasses may be found occupying exacting localities.

Generally speaking, however, the most primitive seek the oldest and most unchanging habitat, while the more advanced prefer the open plains and hills where edaphic and biotic conditions are very diverse. Here the grasses have to be capable of withstanding extremes of heat and cold, extremely different and often rapidly changing edaphic conditions, and are at the same time subjected to fire and grazing. Changes such as these are responsible for progression in many directions and have called forth special adaptations to meet each case.

FOREST AND GRASSLAND CLIMATES

Champion (Ind. For. Rec. Silviculture 1936, Vol. I, No. 1, p. 14) remarks "in India it seems very doubtful if there are any examples of tropical climax grassland, though grassland is common enough as a secondary seral stage and it may be very stable preclimax under the influence of fire and grazing". The author agrees with this belief and with his further opinion (loc. cit.) "the typical savannah type of other countries is also apparently absent

as a true climatic climax, closed deciduous forest grading into thorn forest without any open park-like stage in the absence of biotic influences".

Broadly speaking a favourable climate for the development of grassland as a climax unit would be the following. Frequent precipitation of rain, even if the amount is small, sufficient to keep the upper layers of the soil moist during the vegetative period and sufficient warmth during the growing season.

These demands upon the climate are very modest and something more generous is to be expected everywhere in the Uttar Pradesh. As a more generous climate ultimately leads to the development of a life form higher than that of grass it will be seen that the security of tenure of grass, as a stable vegetational unit, is placed on a very precarious basis.

Precarious though that tenure may be, the stability of grassland over long periods is very well known in India even in the wettest of climates. Factors which aid the grass in a forest climate against the forest may be of two kinds ; edaphic and biotic.

Edaphic factors favourable to the development of grassland rather than forest in a forest climate are usually only transitory. Such soils temporarily reproduce the conditions of grassland climate usually because of their physical characters*. Trees cannot colonize deep drifts of sand because the water-supply in the upper layers is not sufficient for the growth and development of the seedling. Grasses can, however, and do colonize such places but they contribute to their own undoing by adding humus to the soil and making it more retentive of moisture. When this stage is reached tree species can germinate and develop, deriving enough moisture from the upper layers of the soil until they can send down their tap roots to the permanent underground water-supply. Once this stage is reached the grass colonist is ejected or weakened through shade.

Turning now to biotic factors, it is a well-known fact that grassland is burnt frequently. To this factor is also added that of grazing.

Fire alone or fire and grazing combined are very potent factors in keeping grassland stable in a forest climate. The number of trees which will stand fire is small and even they, in years of exceptional drought which makes the grass drier than usual, are burnt to the ground. Therefore, as long as fire is a factor to be contended with the transformation of the grassland into a forest is extremely problematical and uncertain.

If grassland has been in possession of its territory for a number of years it is very difficult for the forest growth to oust it even if the fire factor be absent. Owing to the heavy growth of grass and root competition, forest can only effectively advance from the forest margin. This must necessarily be a very slow process.

THE INDICATOR VALUE OF GRASSES

It is a matter of common knowledge that grassland, which we have seen to be seral in status, exists in several relatively permanent states in the Uttar Pradesh. There is first of all the savannah which consists mainly of tall robust grasses sometimes with small trees scattered over the area. Near villages there are the grazing grounds which support a low turf of creeping grasses. The river banks and sand banks have their own distinctive herbage. The grassy undergrowth of a forest with open canopy will be different from that with a closed canopy. In all these habitats the grass covering appears to be in harmony with its surroundings and is relatively stable as long as the exact conditions under which it is growing remain constant.

* For example a sand bank thrown up by a retreating flood will be covered by xerophilous vegetation no matter what the climate may be. It is a micro-habitat with very dry characteristics.

We can, therefore, equate the grass species of the grassland with the presence or absence, intensity and so on, of certain factors ; in other words, grasses are of value as indicators. Generally speaking perennials are more reliable indicators than annuals. The reason for this is that an annual can complete its life-cycle in a few months and it passes through the unfavourable part of the year in the form of seed. Perennial grasses, by contrast, have to be adapted to all-the-year-round conditions and as such, must of necessity reflect the actual conditions under which they live.

The grasses treated in this paper have been classified according to their minimum requirements of moisture. Attention is invited to the large number which are intermediate in their moisture requirements in proportion to those which prefer the two extreme conditions, desert and swamp. (S) after the name of a species means that it can stand light shade ; (SS) that it can stand deep shade.

VERY DRY

Saccharum spontaneum.
Aristida spp.
Cenchrus ciliaris.
Eragrostis coarctata.

DRY

Andropogon pumilus.
Apluda aristata (S).
Aristida adscensionis.
Aristida cyanantha.
Aristida hystrix.
Arundinella nepalensis (S).
Bothriochloa pertusa.
Cenchrus ciliaris.
Chloris incompleta (S).
Chloris barbata.
Chrysopogon gryllus.
Chrysopogon montanus.
Cymbopogon spp.
Dactyloctenium aegyptium.
Desmostachya bipinnata.
Dichanthium cariocosum.
Eragrostis coarctata.
Eragrostis viscosa.
Eragrostis tremula.
Eulaliopsis binata (S).
Heteropogon contortus.
Imperata cylindrica (S).
Neyraudia arundinacea.
Paspalidium flavidum.
Pennisetum orientale.
Phacelurus speciosus (S).
Saccharum spontaneum.
Sporobolus indicus.
Themeda spp.
Vetiveria zizanioides.

MODERATELY MOIST

Apluda aristata (S).
Arundo donax.
Bothrichloa intermedia.
Chionachne koenigii.
Chloris incompleta.
Chrysopogon aciculatus.
Cynodon dactylon (S).
Dactyloctenium aegyptium.
Dichanthium annulatum.
Digitaria cruciata.
Echinochloa colonum.
Eleusine indica.
Narenga porphyrocoma (S).
Oplismenus spp. (SS).
Panicum spp.
Paspalidium flavidum.
Paspalum scrobiculatum.
Pennisetum orientale.
Phacelurus speciosus (S).
Pseudosorghum fasciculare (S).
Rottboellia exaltata.
Saccharum spontaneum.
Saccharum munja. (*Erianthus munja*).
Saccharum arundinaceum. (*Erinanthus arundinaceus*).

Eragrostis tenella.
Eragrostis unioloides.
Eragrostis chariis.
Erianthus ravennae.
Imperata cylindrica (S).
Ischaemum rugosum.
Iseilema laxum.
Microstegium ciliatum (S).
Sclerostachya fusca.
Sehima nervosum.
Setaria palmaefolia (SS).
Setaria glauca.
Sorghum halepense.
Themeda arundinacea.
Thysanolaena maxima (S).
Vetiveria zizanioides.

WET

Arundo donax.
Coix lachryma-jobi.
Imperata cylindrica.
Panicum paludosum.
Phragmites karka.
Saccharum arundinaceum. (*Erainthus arundinaceus*).
Saccharum spontaneum.

It will be seen that one grass only is found in all the four habitats. This species is that very remarkable grass *Saccharum spontaneum*. Dr. Janaki Ammal has shown that the different forms of this plant constitute a polyploid series with chromosome numbers (2n) varying from 48 to 80. This in itself is worthy of note but far more remarkable is the tolerance which this species exhibits towards widely varying soil conditions. To be successful as a colonist a plant must possess such powers of accommodation. A successful colonist must also possess seeds which are blown about by the wind or are furnished with some other means of ensuring wide dispersal of its seed. *S. spontaneum* is well equipped in this respect. Furthermore successful migration is assured if viable seeds are produced in abundance at a time of the year when bare areas are likely to occur and are available for colonization. It will be seen the *S. spontaneum* "fills the bill" in this respect also.

During the rains there is always heavy precipitation in the foothills of the Himalaya and consequently floods in the alluvial streams which meander from the foothills to the larger rivers. At the end of the rains when the flooded rivers subside bare areas such as sand banks, eroded pastures and the like are exposed to view. *Saccharum spontaneum* is well known as the grass which flowers towards the end of the rains and the ripe seeds, so light that they easily float on the air, are just ready when the flood waters begin to subside. The seeds germinate in their new home and it matters little whether this new home is sand or a stiff wet clay, the seedling can adapt itself to both these two and any other condition. *Saccharum spontaneum* has no rival at this time of the year and its presence on all river banks and sand banks is no accident of nature, but the inevitable result of its ecological equipment.

This grass can hold its own against *Imperata cylindrica* on soil which is too dry for the latter and also on soils which are too heavy and wet, but in habitats with intermediate conditions *Imperata* usually wins the struggle. The deciding factor is fire and it is ironical that the very character which enables *S. spontaneum* to be a successful colonizer, that of early flowering and fruiting, is the one which is a definite handicap when it comes to a fight between it and *Imperata cylindrica*. In fire swept savannah the bare areas due to the fires occur at a time which is favourable to *Imperata* but not to *Saccharum*, for the former produces viable seeds in quantity about the time the jungle fires are over. *Imperata* has, therefore, every chance of extending its range at the expense of *Saccharum spontaneum.*

Imperata cylindrica, the *alang-alang* of Malaya, takes possession of abandoned cultivation in the most remarkable fashion and many instances of this are to be seen all over the tropics in forest climates.

Junghuhn's description of the spread of this grass, even though it borders on the picturesque, is well worth reproducing.

"When the soil remains uncultivated after clearing the forest, as a rule the social and dense-growing *alang*-grass first replaces the vanished forests, then areas extending for miles, even indeed for whole days' journeys, are transformed into a uniform wilderness of dense grass three to five feet high, while on mountain-slopes the same grass extends far beyond its original zone, and spreading over everything it ranges up to altitude of 6,000–7,000 feet, being almost insensible to differences of temperature. Its silken haired seeds, light as the tenderest down, are wafted away in millions by the slightest breath of wind and greatly facilitate its general distribution, while its creeping and deeply penetrating roots increase the difficulty of eradication when once this grass, so tenacious of life, has established itself. I have reasons for believing that while the land was in its original condition the *alang*-grass was restricted to sundry sterile, arid, waterless tracts of the hot zone, and was chiefly confined to heavy, hard, easily dried clay soil, with an iron-pan, but that at the present time, wherever we meet this grass on a fertile light soil and on mountain-slopes at above 2,000 feet, this state of affairs is first brought about by the hand of man...... In Northern Sumatra, especially in the Batta country that has been devastated by war, grassy wastes have consequently come into existence which cover everything far and wide with a hideous uniformity and over-run plain, mountain, and valley with their whitish-green mantle".

Noteworthy is the manner in which *Sclerostachya fusca* follows the course of shallow surface channels which only carry water during the rains. Such places are slightly moister than the surrounding habitat and have usually a higher clay content. *Narenga porphyrocoma* is considered to be indicative of conditions suitable for the natural regeneration of *sal*, i.e., a light, porous well-drained soil.

Wet and waterlogged areas are habitats to which only specially adapted grasses can migrate. Apart from certain floating grasses the species which is most at home in such places is undoubtedly *Phragmites karka*. *Panicum paludosum* too, prefers very wet places and the following migrate into such habitats in varying degrees: *Arundo donax*, *Coix lachryma-jobi*, *Ischaemum rugosum*, *Saccharum spontaneum* and *Imperata cylindrica*. On the other hand *Aristida* spp., *Cenchrus ciliaris* and *Eragrostis coarctata* are at home in dry stony inhospitable places.

So far we have only considered grasses of the savannah and river banks where they are subject to edaphic factors and the biotic factor fire. It is well known that the edaphic factors have a great influence on vegetation in course of development and that the biotic factor fire can terminate and hold stationary a developing community. We have not yet considered the effect of adding another biotic factor, grazing, to the operative edaphic and biotic factors; in other words, if the conditions of the village grazing grounds are reproduced.

In such a case there is a rapid and progressive change from the robust grasses of the savannah to smaller and hardier forms. This is the retrogression, backward succession, degeneration, etc. It is, however, nothing more or less than destruction and the change is proportional to the intensity of the grazing. If the grazing grounds are managed under some system whereby areas are given a rest in rotation, little harm is done and grass will continue to be produced in quantity. If, however, the intensity of grazing is considerable, the productivity of the grazing ground becomes very much reduced and the only grasses which survive are low creeping species with meagre foliage. Eventually of course, even these species must disappear.

The change from tall savannah to close turf is often startling and the rapid change in species even more so. There is one species of the savannah which does survive on the

village grazing ground. This is that ubiquitous grass, *Imperata cylindrica*, which meets adverse circumstance by the assumption of its depauperate form. In this form the plant is at most 9 in. high and to save reserves of food material only the minimum amount of leaf surface compatable with the needs of existence is produced. This is economy with a vengeance but it pays, for if such a grazing ground is protected from fire and grazing, *Imperata* at once becomes dominant.

In addition to *Imperata cylindrica, Dichanthium annulatum, Chrysopogon aciculatus* and *Bothriochloa pertusa* are the grasses most frequently found in grazing grounds. These grasses maintain themselves because of their perennial and prostrate habit whereby the stem is pegged down to the soil by rootlets from the nodes. These grasses are obviously well suited to the browsing and trampling of the grazing ground. It is, therefore, with some surprise that one observes that a different species usurps well-trodden paths across these areas. This grass, *Cynodon dactylon*, is almost invariably found on such paths. On the paths another factor has been added to the browsing and tramping of hooves, namely, the rolling pressure of the human foot. The *andropogonous* grasses mentioned above are unable to stand this additional factor while the *Cynodon* can.

The above paragraphs show how the grass flora as well as the other plants which go to make up the undergrowth in a forest or the dominant vegetation in the open, is of importance because of the information it can give of the conditions of the habitat, to those who are in a position to read the signs.

GRAZING IN THE FOREST

The question of providing grazing for village cattle in the forest is one that has become of increasing importance to forest officers during the past decade. It is hardly necessary to point out that all types of forest do not produce grass and that a system of management, whose object is the production of high class timber, may not be a popular one with the surrounding villagers. In Assam the grazing of village cattle is regarded as an aid in certain stages in the natural regeneration of *sal*, but on the other hand the potential dangers arising from uncontrolled grazing in a forest require no emphasis. Eventually of course there must be some kind of compromise and in most of the Working Plans the provision of forest grazing for village cattle is the subject of special prescriptions.

In the past the Forest Department has attempted to discourage the influx of large numbers of cattle by the imposition of a grazing fee. The levy of a reasonably heavy fee discourages grazing but arouses discontent. The reduction of the fee to a nominal figure has as its natural corollary the over-running of the forest by hordes of cattle and goats, the deterioration of the fodder and increase in the danger of erosion. These are dangers which no body can view with equanimity.

The great problem lies in the fact that herds of village cattle contain a very large proportion of worthless individuals which, nevertheless, eat as much grass as more worthy animals. The obvious solution of this problem is a curtailment of the present promiscuous breeding of cattle and the destruction of the worthless mouths. In India, of course, the destruction of cattle, no matter how old, diseased or suffering, would not be tolerated for a moment and woe betide any Government which prescribes it. Upgrading of stock by careful cross breeding, artificial insemination and by castration of scrub bulls are all being attemped. But there is no use of improving the stock unless the fodder supply is also improved.

IMPROVEMENT OF FODDER SUPPLIES

A certain quantity of fodder, exotic grasses and legumes are being grown specially for cattle, but the extent grown and the quantity produced hardly make any appreciable

contribution to the total fodder output of the country. Improvement of forest and waste land pasture has been attempted by introducing rotational grazing, periodic grazing and by growing artificially good palatable strains of grasses. These have not yielded the expected results, as one vital necessity for any improvement of pasture is the power to restrict and vary the total number of cattle grazing in an area. The period during which the cattle can graze should also be capable of adjustment. Unfortunately such a power does not exist, but where it has been possible to impose such a restriction with the willing consent of the public better grazing grounds have become available. All these, however, are problems of grazing or pasture management and as such beyond the scope of this paper.

CONSPECTUS OF THE TRIBES AND SUB-TRIBES OF THE GRAMINEAE

Family Gramineae

Sub-family I. POOIDEAE

Tribe I.—*Bambuseae*
Tribe II.—*Pappophoreae*
Tribe III.—*Festuceae*
Tribe IV.—*Hordeeae*
Tribe V.—*Arundineae*
Tribe VI.—*Eragrosteae.*
Tribe VII.—*Sporoboleae.*
Tribe VIII.—*Chlorideae.*
Tribe IX.—*Aveneae.*
Tribe X.—*Agrosteae.*
Tribe XI.—*Stipeae.*
Tribe XII.—*Phalarideae.*
Tribe XIII.—*Oryzeae.*
Tribe XIV.—*Zoiseae.*
Tribe XV.—*Thysanolaeneae.*
Tribe XVI.—*Arundinelleae.*

Sub-family II. PANICOIDEAE

Tribe I.—*Paniceae.*
Tribe II.—*Andropogoneae.*
  Sub-tribe I.—*Dimerinae.*
  Sub-tribe II.—*Saccharinae.*
  Sub-tribe III.—*Ischiminae.*
  Sub-tribe IV.—*Rottboellinae.*
  Sub-tribe V.—*Sorghinae.*
  Sub-tribe VI.—*Andropogoninae.*
Tribe III.—*Maydeae.*

LIST OF THE GRASSES OF THE UPPER GANGETIC PLAIN

Sub-family I. **POOIDEAE**

Tribe I. *Bambuseae*

BAMBUSA Schreb.

**Bambusa nutans* Wall. (F.B.I. 387).
Bambusa bambos (Linn.) Voss (*Bambusa arundinacea Auct. non* Willd. F.B.I. 395).

DENDROCALAMUS Nees

Dendrocalamus strictus Nees (F.B.I. 404).
**Dendrocalamus hamiltonii* Nees & Arn. (F.B.I. 405).

Tribe II. *Pappophoreae*

ENNEAPOGON Desv.

Enneapogon cenchroides (Licht. ex R. & S.) C. E. Hubb. (*Pappophorum robustum* Hook. f. F.B.I. 302).

Tribe III. *Festuceae*

POA Linn.

Poa annua Linn. (F.B.I. 345).

LOLIUM Linn.

Lolium temulentum Linn. (F.B.I. 364).

Tribe IV. *Hordeeae*

HORDEUM Linn.

Hordeum vulgare Linn. (F.B.I. 371).

TRITICUM Linn.

**Triticum aestivum* Linn. (*Triticum vulgare* Vill. F.B.I. 361).

Tribe V. *Arundineae*

ARUNDO Linn.

Arundo donax Linn. (F.B.I. 302).

PHRAGMITES Trin.

Phragmites maxima Chiovenda (*Phragmites karka* Trin. ex Steud. and *Phragmites communis* Trin. F.B.I. 304).

Tribe VI. *Eragrosteae*

DESMOSTACHYA Stapf

Desmostachya bipinnata (Linn.) Stapf (*Eragrostis cynosuroides* Beauv. F.B.I. 324).

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* An asterisk in front of a name means that the particular species has been introduced.

ELYTROPHORUS Beauv.

Elytrophorus spicatus A. Camus (*Elytrophorus articulatus* P. Beauv. F.B.I. 306).

ERAGROSTIS Beauv.

Eragrostis coarctata Stapf ex Hook. f. (F.B.I. 313).
Eragrostis ciliaris (Linn.) Link. (F.B.I. 314).
Eragrostis unioloides (Retz.) Nees ex Steud. (*Eragrostis ambilis* Wight & Arn. ex Nees F.B.I. 317).
Eragrostis tenella R. & S. (F.B.I. 315).
Eragrostis viscosa Trin. (F.B.I. 315).
Eragrostis diarrhena Steud. (*Eragrostis interrupta* Beauv. var. *diarrhena* Stapf (F.B.I. 316).
Eragrostis japonica Trin. (*Eragrostis interrupta* var. *tenuissima* Stapf in F.B.I. 316).
Eragrostis chariis (*Schult.*) Hitchc. (*Eragrostis elegantula* Steud. F.B.I. 318).
Eragrostis cilianensis (All.) Link. ex Lutati (*Eragrostis major* Hochst. F.B.I. 320).
Eragrostis tenuifolia (A. Rich.) Hochst. (F.B.I. 322).
Eragrostis pilosa (Linn.) Beauv. (F.B.I. 323).

ELEUSINE Gaertn.

Eleusine indica (Linn.) Gaertn. (F.B.I. 293).
Eleusine flagellifera Nees (F.B.I. 294).
†*Eleusine verticillata* Roxb. (F.B.I. 295).

DACTYLOCTENIUM Willd.

Dactyloctenium aegyptium (Linn.) P. Beauv. (*Eleusine aegyptiaca* Desf. F.B.I. 295).
Dactyloctenium scindicum Boiss. (*Eleusine aristata* Ehrenb. F.B.I. 296).

TRIPOGON Roth.

Tripogon lisboae Stapf (F.B.I. 286).

LEPTOCHLOA P. Beauv.

Leptochloa filiformis R. & S. (F.B.I. 298).
Leptochloa chinensis Nees (F.B.I. 299).

NEYRAUDIA Hook. f.

Neyraudia arundinacea (Linn.) Henr. (*Neyraudia madagascariensis* Hook. f. F.B.I. 305).

ERAGROSTIELLA Bor

Eragrostiella brachyphylla (Stapf) Bor (*Eragrostis brachyphylla* Stapf F.B.I. 327).
Eragrostiella bifaria (Vahl.) Bor (*Eragrostis coromandelina* Trin. F.B.I. 326).
Eragrostiella nardoides (Trin.) Bor (*Eragrostis nardoides* Trin. F.B.I. 326).

† The correct name of this grass is *Acrachne racemosa* (Heyne) Ohwi in Bull. Tokyo Sci. Mus. n. 18, 1 (1947).

DINEBRA Jacq.

Dinebra retroflexa (Vahl.) Panzer (*Dinebra arabica* Jacq. F.B.I. 297).

DIPLACHNE P. Beauv.

Diplachne fusca Beauv. (F.B.I. 329).

Tribe VII. *Sporoboleae*

SPOROBOLUS Br.

Sporobolus tremulus Kunth (F.B.I. 250).
Sporobolus coromandelianus (Retz.) Kunth (F.B.I. 252).
Sporobolus pallidus Boiss. (*Sporobolus arabicus* Boiss. F.B.I. 252).
Sporobolus diander Beauv. (F.B.I. 247).
Sporobolus indicus R. Br. (F.B.I. 248).
Sporobolus orientalis Kunth (F.B.I. 252).

Tribe VIII. *Chlorideae*

CHLORIS Sw.

Chloris pallida Hook. f. (F.B.I. 289).
Chloris virgata Sw. (F.B.I. 291).
Chloris myosuroides Hook. f. (F.B.I. 290).
Chloris incompleta Roth (F.B.I. 290).
Chloris barbata Sw. (F.B.I. 292).
Chloris montana Roxb. (F.B.I. 292).

TETRAPOGON Desf.

Tetrapogon tenellus Chiov. (*Chloris tenella* Roxb. F.B.I. 291).
Tetrapogon villosus Desf. (*Chloris villosus* Pers. F.B.I. 291).

CYNODON Rich.

Cynodon dactylon (Linn.) Pers. (F.B.I. 288).

MELANOCENCHRIS Nees

Melanocenchris jacquemontii Jaub. and Spach. (*Gracilea royleana* Hook. f. F.B.I. 284).

OROPETIUM Trin.

Oropetium thomaeum Trin. (F.B.I. 366).

Tribe IX. *Aveneae*

AVENA Linn.

**Avena sterilis* Linn. var. culta. (*Avena sativa* Auct. *non* Linn. F.B.I. 275).

* An asterisk in front of a name means that the particular species has been introduced.

Tribe X. *Agrosteae*

MUEHLENBERGIA Schreb.

Muehlenbergia huegelii Trin. (*Muehlenbergia viridissima* Nees ex Steud. F.B.I. 259).
**Muehlenbergia mexicana* Trin. (not in F.B.I.).

POLYPOGON Desf.

Polypogon fugax Nees ex Steud. (under *Polypogon monspeliensis* Desf. in part F.B.I. 245).
Polypogon monspeliensis Desf. (F.B.I. 245).

ALOPECURUS Linn.

Alopecurus nepalensis Trin. (F.B.I. 239).

HELEOCHLOA Host.

†*Heleochloa schoenoides* Host. (F.B.I. 235).

Tribe XI. *Stipeae*

ARISTIDA Linn.

Aristida redacta Stapf (F.B.I. 227).
Aristida hystricula Edgew. (F.B.I. 227).
Aristida funiculata Trin. & Rupr. (F.B.I. 226).
Aristida hystrix Linn. f. (F.B.I. 225).
Aristida cyanantha Steud. (F.B.I. 225).
Aristida adscenscionis Linn. (F.B.I. 224).
**Aristida setacea* Retz. (F.B.I. 225).

Tribe XII. *Phalarideae*

PHALARIS Linn.

Phalaris minor Retz. (F.B.I. 221).

Tribe XIII. *Oryzeae*

ORYZA Linn.

**Oryza sativa* Linn. (F.B.I. 92).

HYGRORYZA Nees

Hygroryza aristata Nees (F.B.I. 95).

Tribe XIV. *Zoiseae*

PEROTIS Ait.

Perotis indica Kuntze (*Perotis latifolia* Ait. F.B.I. 98).

TRAGUS Haller.

Tragus biflorus Schult. (*Tragus racemosus* Scop. F.B.I. 97).

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† The correct name is *Crypsis schoenoides* (Linn.) Lam. – See Hubbard in Hk. Ic. Pl. subtab. 3451 (1947.) This genus has been transferred to Sporoboleae.

Tribe XV. *Thysanolaeneae*

THYSANOLAENA Nees

Thysanolaena maxima Ktze. (*Thysanolaena agrostis* Nees F.B.I. 61).

Tribe XVI. *Arundinelleae*

ARUNDINELLA Raddi

Arundinella bengalensis Druce (*Arundinella wallichii* Nees F.B.I. 75).
Arundinella fuscata Nees ex Buse (F.B.I. 74).
Arundinella pumila (Hochst.) Steud. (*Arundinella tenella* Nees & Wt. F.B.I. 71.).
Arundinella nepalensis Trin. (*Arundinella brasiliensis* F.B.I. 73 *non* Raddi).
Arundinella tuberculata Munro ex Lisboa (F.B.I. 69).

Sub-family II. **PANICOIDEAE**

Tribe I. *Paniceae*

ISACHNE R. Br.

Isachne dispar Trin. (F.B.I. 26).

Digitaria Heist. ex Fabr.

Digitaria adscendens (H.B.K.) Henr. subsp. *chrysoblephara* (Fig. et De Not.) Henr. & subsp. *marginata* (Link.) Henr. (*Paspalum sanguinale* Lamk. in part F.B.I. 13).
Digitaria bicornis (Lamk.) R. & S. (*Paspalum sanguinale* Lamk. in part F.B.I. 13).
Digitaria biformis Willd. (*Paspalum sanguinale* Lamk. in part F.B.I. 13).
Digitaria pennata (Hochst.) Chiov. (*Paspalum pennatum* Hook. f. F.B.I. 16).
Digitaria granularis (Trin.) Henr. (*Paspalum pedicellare* Trin. ex Steud. F.B.I. 19).
Digitaria stricta Roth (*Paspalum royleanum* Nees ex Thw. F.B.I. 18).
Digitaria longiflora (Retz.) Pers. (*Paspalum longiflorum* Retz. F.B.I. 17).
Digitaria duthieana Henr. ex Bor.
Digitaria corymbosa (Roxb.) Merr. (*Paspalum sanguinale* Lamk. var. *extensum* Hook. f. F.B.I. 15).
Digitaria cruciata (Nees) Camus (*Paspalum sanguinale* var. *cruciatum* Hook. f. F.B.I. 14).
Digitaria microbachne (Presl.) Henr.
Digitaria setigera Roth.
Digitaria preslii (Kunth) Henr.
Digitaria timorense (Kunth) Balansa (*Paspalum sanguinale* Lamk. var. *debile* F.B.I. 16).
Digitaria sanguinale (L.) Scop. subsp. *vulgaris* (Schrad.) Henr. var. *rottleriana* Henr. (*Paspalum sanguinale* Lamk. in part F.B.I. 15).

ALLOTEROPSIS Presl., emend. Hitch

Alloteropsis cimicina Stapf (*Axonopus cimicinus* Beauv. F.B.I. 64).

SACCIOLEPIS Nash

Sacciolepis interrupta (Willd.) Stapf (*Panicum interruptum* Willd. F.B.I. 40).
Sacciolepis indica (Linn.) Chase (*Panicum indicum* Linn. F.B.I. 41).
Sacciolepis myosuroides (R. Br.) Chase (*Panicum myosuroides* R. Br. F.B.I. 42).

HYMENACHNE P. Beauv.

Hymenachne amplexicaulis (Rudge) Nees (*Panicum myurus* H. B. & K. F.B.I. 39).

PANICUM Linn.

Panicum trypheron Schult. (F.B.I. 47).
Panicum austroasiaticum Ohwi (*Panicum humile* Nees ex Steud. F.B.I. 48).
Panicum miliare Lamk. (F.B.I. 46).
Panicum psilopodium Trin. (F.B.I. 46).
Panicum paludosum Roxb. (*Panicum proliferum* Hook. f. F.B.I. 60).
Panicum repens Linn. (F.B.I. 49).
Panicum bisulcatum Thunb. *Panicum acroanthum* Steud. (F.B.I. 52).
Panicum antidotale Retz. (F.B.I. 52).
Panicum montanum Roxb. (F.B.I. 53).
**Panicum maximum* Jacq. (F.B.I. 49).
Panicum atrosanguineum Hochst. ex A. Rich. (*Panicum hydaspicum* Edgw. F.B.I. 48).
Panicum miliaceum Linn. (F.B.I. 45).

CYRTOCOCCUM Stapf

Cyrtococcum patens (Linn.) A. Camus (*Panicum patens* Linn. F.B.I. 57).

ECHINOCHLOA P. Beauv.

Echinochloa crus-galli (Linn.) P. Beauv. (*Panicum crus-galli* Linn. partim F.B.I. 30).
Echinochloa colonum (Linn.) Link. (*Panicum colonum* Linn. F.B.I. 32).
Echinochloa stagnina (Retz.) Beauv. (*Panicum crus-galli* Linn. partim F.B.I. 30).

PASPALUM Linn.

Paspalum distichum Linn. (F.B.I. 12).
Paspalum scrobiculatum Linn. (F.B.I. 10).

PASPALIDIUM Stapf

Paspalidium flavidum (Retz.) Camus (*Panicum flavidum* Retz. F.B.I. 28).
Paspalidium geminatum (Forsk.) Stapf (*Panicum paspaloides* Pers. F.B.I. 30).
Paspalidium punctatum (Burm.) Camus (*Paspalum punctatum* Burm. F.B.I. 29).

UROCHLOA P. Beauv.

Urochloa helopus (Trin.) Stapf (*Panicum javanicum* Hook. f. F.B.I. 35).

OPLISMENUS P. Beauv.

Oplismenus burmannii (Retz.) P. Beauv. (F.B.I. 68).
Oplismenus compositus (Linn.) P. Beauv. (F.B.I. 66).

* An asterisk in front of a name means that the particular species has been introduced.

ERIOCHLOA H. B. & K.

Eriochloa procera (Retz.) C. E. Hubb. (*Eriochloa polystachya* H.B.K. F.B.I. 20).

BRACHIARIA Griseb.

Brachiaria reptans (Linn.) Gard. et Hubb. (*Panicum prostratum* Lamk. F.B.I. 33).
Brachiaria eruciformis (Sibth. et Smith) Griseb. (*Panicum isachne* Roth ex R. & S. F.B.I. 28).
Brachiaria distachya (Linn.) Stapf (*Panicum distachyum* Linn. F.B.I. 37).
Brachiaria ramosa (Linn.) Stapf (*Panicum romosum* Linn. F.B.I. 36).
Brachiaria deflexa (Schum.) C. E. Hubbard ex Robyns. (not in F.B.I.).
Brachiaria kurzii (Hook. f.) A. Camus (*Panicum kurzii* Hook. f. F.B.I. 38).

STENOTAPHRUM Trin.

Stenotaphrum dimidiatum Brongn. (*Stenotaphrum glabrum* Hook. f. F.B.I. 90).

SETARIA Beauv.

Setaria palmaefolia Stapf (*Panicum plicatum* Lam. F.B.I. 55).
Setaria homonyma (Steud.) Chiov. (*Panicum rhachitrichum* Hook. f. F.B.I. 56).
Setaria forbesiana Hook. f. (F.B.I. 81).
Setaria italica Beauv. (F.B.I. 78).
Setaria glauca Beauv. (F.B.I. 78).
Setaria pallide-fusca Stapf (not in F.B.I.).
Setaria tomentosa (Raxb.) Kunth (*Setaria intermedia* Roem. & Schult. F.B.I. 79).
Setaria verticillata Beauv. (F.B.I. 80).

PSEUDORAPHIS Griff.

Pseudoraphis aspera (Koenig) Pilger (*Chamaeraphis spinescens* Poir, F.B.I. 62).

PENNISETUM Rich.

Pennisetum hohenackeri Hochst. ex Steud. (*Pennisetum alopecurus* Steud. F.B.I. 84).
Pennisetum pedicellatum Trin. (F.B.I. 86).
Pennisetum hordeoides Steud. (*Pennisetum parviflorum* Trin. F.B.I. 86).
Pennisetum polystachyon Schult. (F.B.I. 87).
**Pennisetum typhoides* Stapf & Hubb. (*Pennisetum typhoideum* Rich. F.B.I. 82).

CENCHRUS Linn.

Cenchrus prieurii (Kunth) Maire (*Pennisetum prieurii* Kunth F.B.I. 89).
Cenchrus ciliaris Linn. (*Pennisetum cenchroides* Rich. F.B.I. 88).
Cenchrus setigerus Vahl. (*Cenchrus biflorus* F.B.I. 89, *non* Roxb.).
Cenchrus pennisetiformis Hochst. & Steud. (*Pennisetum cenchroides* Rich. var. echioides Hook. f. F.B.I. 88).
Cenchrus biflorus Roxb. (*Cenchrus catharticus* Del. F.B.I. 90).

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RHYNCHELYTRUM Nees

Rhynchelytrum villosum Chiov. (*Tricholaena wightii* Nees & Arn. F.B.I. 65).

Tribe II. *Andropogoneae*

Sub-tribe I. *Dimerinae*

DIMERIA R. Br.

Dimeria connivens Hack. (F.B.I. 104).
Dimeria ornithopoda Trin. (F.B.I. 104).

Sub-tribe II. *Saccharinae*

IMPERATA Cyrill

Imperata cylindrica (Linn.) P. Beauv. (*Imperata arundinacea* Cyrill F.B.I. 106).

SCLEROSTACHYA A. Camus

Sclerostachya fusca (Roxb.) A. Camus (*Saccharum fuscum* Roxb. F.B.I. 120).

NARENGA Bor

Narenga porphyrocoma (Hance) Bor (*Saccharum narenga* Wall. F.B.I. 267).

SACCHARUM Linn.

Saccharum spontaneum Linn. (F.B.I. 118).
**Saccharum officinarum* Linn. (F.B.I. 118).

ERIANTHUS Michx.

Erianthus ravennae (Linn.) P. Beauv. (F.B.I. 121).
Erianthus versicolor Nees ex Steud. (F.B.I. 124).
Erianthus longisetosus Anders. (F.B.I. 124).
Erianthus hookeri Hack. (F.B.I. 125).
Erianthus munja (Roxb.) Jeswiet (*Saccharum arundinaceum* Retz. partim F.B.I. 119).
Erianthus arundinaceus (Retz.) Jesweit (*Saccharum arundinaceum* Retz. F.B.I. 119 excl. syn. *S. ciliare* Anders. *S. exaltatum* Roxb. *S. sara* Roxb. *S. munja* Roxb. *S. procerum* Roxb.).
Erianthus procerus (Roxb.) Raizada comb. nov. (F.B.I. 119 under *Saccharum arundinaceum* Retz.).

PSEUDOPOGONATHERUM A. Camus

Pseudopogonatherum contortum (Brongn.) A. Camus (*Pollinia articulata* Trin. F.B.I. 109).

EULALIA Kunth

Eulalia trispicata (Schult.) Henr. (*Pollinia argentea* Trin. F.B.I. 111).
Eulalia fastigiata (Nees) Stapf (*Erianthus fastigiatus* Nees ex Steud. F.B.I. 125).
Eulalia cummingii (Nees) A. Camus (*Pollinia cummingii* Nees F.B.I. 114).

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EULALIOPSIS Honda

Eulaliopsis binata (Retz.) Hubb. (*Ischaemum angustifolium* Hack. F.B.I. 129).

POGONATHERUM P. Beauv.

Pogonatherum paniceum (Lam.) Hack. (*Pogonatherum saccharoideum* P. Beauv. F.B.I. 141).

APOCOPIS Nees

Apocopis paleaceus (Trin.) Hochr. (*Apocopis royleanus* Nees F.B.I. 142).
Apocopis vaginatus Hack. (*Apocopis wightii* Nees ex Steud. var. *vaginatus* Hook. f. F.B.I. 142).

MICROSTEGIUM Nees

Microstegium ciliatum (Trin.) A. Camus (*Pollinia ciliata* Trin. F.B.I. 116).
Microstegium nudum (Trin.) A. Camus (*Pollinia nuda* Trin. F.B.I. 117).

Sub-tribe III. *Ischiminae*

SEHIMA Forsk.

Sehima nervosum (Rottl.) Stapf (*Ischaemum laxum* R. Br. F.B.I. 136).
Sehima sulcatum (Hack.) A. Camus (*Ischaemum sulcatum* Hack. F.B.I. 137).

ISCHAEMUM Linn.

Ischaemum aristatum Linn. (*Ischaemum ciliare* Retz. F.B.I. 133).
Ischaemum rugosum Salisb. (F.B.I. 127).
Ischaemum molle Hook. f. (F.B.I. 128).
Ischaemum hirtum Hack. partim (F.B.I. 135).

THELEPOGON Roth ex R. & S.

Thelepogon elegans. Roth ex R. & S. (F.B.I. 148).

APLUDA Linn.

Apluda mutica Linn. var. *eumutica* (Linn.) Pilger (*Apluda varia* Hack. sub. sp. *mutica* Hack. F.B.I. 150).

Apluda mutica Linn. var. *aristata* (Linn.) Pilger (*Apluda varia* Hack. sub. sp. *aristata* Hack. F.B.I. 150).

Sub-tribe IV. *Rottboellinae*

HACKELOCHLOA O. Kuntze

Hackelochloa granularis (Linn.) Ktze. (*Manisuris granularis* Linn. f. F.B.I. 159).

ELYONURUS Humb. et Bonpl.

Elyonurus royleanus Nees ex A. Rich. (F.B.I. 161).

* An asterisk in front of a name means that the particular species has been introduced.

HEMARTHRIA R. Br.

Hemarthria compressa (Linn. f.) R. Br. (*Rottboellia compressa* Linn. f. partim. F.B.I. 153).

ROTTBOELLIA Linn. f.

Rottboellia exaltata Linn. f. (F.B.I. 156).

MNESITHEA Kunth

Mnesithea laevis (Retz.) Kunth (*Rottboellia perforata* Roxb. F.B.I. 158).

OPHIURUS Gaertn. f.

Ophiurus exaltatus (Linn.) Ktze. (*O. corymbosus* Hook. f. F.B.I. 160 partim).

THAUMASTOCHLOA Hubb.

Thaumastochloa cochinchinensis (Lour.) Hubb. (not in F.B.I.).

Sub-tribe V. *Sorghinae*

SORGHUM Adans.

Sorghum halepense (Linn.) Pers. (*Andropogon halepensis* Brot. F.B.I. 182).
Sorghum nitidum (Vahl.) Pers. (*Andropogon serratus* Thunb. F.B.I. 185).
**Sorghum vulgare* Pers. (*Andropogon sorghum* Brot. F.B.I. 183).
Sorghum deccanense Stapf ex Raizada nomen nova. (*Andropogon purpureo-sericeus* Hook. f. (non Hochst.) F.B.I. 185).

CHRYSOPOGON Trin.

Chrysopogon gryllus (Linn.) Trin. (*Andropogon gryllus* Linn. F.B.I. 187).
Chrysopogon montanus Trin. (*Andropogon monticola* Schult. F.B.I. 192).
Chrysopogon aciculatus (Retz.) Trin. (*Andropogon aciculatus* Retz. F.B.I. 188).
Chrysopogon polyphyllus (Hack.) Blatter & McCann (*Andropogon polyphyllus* Hack. F.B.I. 194).

VETIVERIA Bory

Vetiveria zizanioides (Linn.) Nash (*Andropogon squarrosus* Hook. f. *non* Linn. F.B.I. 186).

Sub-tribe VI. *Andropogoninae*

CAPILLIPEDIUM Stapf

Capillipedium parviflorum (Br.) Stapf (*Andropogon micranthus* Kunth F.B.I. 178).
Capillipedium hugelii (Hack.) A. Camus (*Andropogon schmidii* Hook. f. F.B.I. 180).
Capillipedium assimile (Steud.) A. Camus (*Andropogon assimilis* Steud. F.B.I. 179).

PSEUDOSORGHUM A. Camus

Pseudosorghum fasciculare (Roxb.) Camus (*Andropogon fascicularis* Roxb. F.B.I. 177).

* An asterisk in front of a name means that the particular species has been introduced.

BOTHRIOCHLOA O. Kuntze

Bothriochloa kuntzeana (Hack.) Henr. (*Andropogon kuntzeanus* Hack. F.B.I. 175).

Bothriochloa pertusa (Linn.) Camus (*Andropogon pertusus* Willd. F.B.I. 173).

Bothriochloa glabra (Roxb.-) Camus (*Andropogon intermedius* Hook. f. *non* Br. F.B.I. 175).

Bothriochloa intermedia (Br.) Camus (*Andropogon intermedius* Br. var. *punctatus* F.B.I. 176).

DICHANTHIUM Willem.

Dichanthium annulatum (Forsk). Stapf (*Andropogon annulatus* Forsk. F.B.I. 196).

Dichanthium caricosum (Linn.) Camus (*Andropogon caricosus* Linn. var. *genuinus* Hack. F.B.I. 196).

Dichanthium aristatum (Poir.) C. E. Hubb. (*Andropogon caricosus* Linn. var. *mollicomus* Hack. F.B.I. 196).

ARTHRAXON P. Beauv.

Arthraxon quartinianus Nash (under A. ciliaris F.B.I. 146).

Arthraxon lancifolius (Trin.) Hochst. (*A. microphyllous* Hochst. F.B.I. 147).

Arthraxon nudus Hochst. (*A. ciliaris* F.B.I. 146, partim).

Arthraxon serrulatus Hochst. (*Arthraxon lanceolatus* Hochst. F.B.I. 143, partim).

CYMBOPOGON Spreng.

Cymbopogon osmastonii Parker (not in F.B.I.).

Cymbopogon distans (Nees ex Steud.) Watson (*Andropogon distans* Nees ex Steud. F.B.I.207).

Cymbopogon khasianus (Munro) Stapf ex Bor (*Andropogon nardus* Linn. var. *khasianus* Hack. F.B.I. 206).

Cymbopogon martinii (Roxb.) Wats. (*Andropogon schoenanthus* Linn. var. *martinii* Hook. f. F.B.I. 204).

Cymbopogon stracheyi (Hook. f.) Raizada & Jain status nov. (*Andropogon nardus* Linn. var. *stracheyi* F.B.I. 207).

Cymbopogon jwarancusa (Jones) Schult. (*Andropogon jwarancusa* Jones subsp. *jwarancusa* F.B.I. 203).

Cymbopogon parkeri Stapf (not in F.B.I.).

**Cymbopogon nardus* (Linn.) Rendle (*Andropogon nardus* Linn. vars. *culata* and *genuina* F.B.I. 206).

Cymbopogon flexuosus (Nees) Watson (*Andropogon nardus* Linn. var. *flexuosus* Hack. F.B.I. 207).

ANDROPOGON Linn.

Andropogon pumilus Roxb. (F.B.I. 170).

PSEUDANTHISTIRIA Hook. f.

Pseudanthistiria hispida Hook. f. (F.B.I. 219).

* An asterisk in front of a name means that the particular species has been introduced.

EREMOPOGON Stapf

Eremopogon strictus (Roxb.) Camus (*Andropogon foveolatus* Del. F.B.I. 168).

DIECTOMIS Kunth

Diectomis fastigiata (Sw.) Kunth (*Andropogon fastigiatus* Sw. F.B.I. 167).

SCHIZACHYRIUM Nees

Schizachyrium brevifolium Nees (*Andropogon brevifolium* Sw. F.B.I. 165).
Schizachyrium exile (Hochst.) Stapf (*Andropogon exilis* Hochst. F.B.I. 166).

THEMEDA Forsk.

Themeda quadrivalvis O. Ktz. (*Anthistiria ciliata* Linn. f. F.B.I. 213).

Themeda strigosa (Ham.) A. Camus (*Anthistiria strigosa* Ham. ex Hook. f. F.B.I. 214).

Themeda arundinaceae (Roxb.) Ridley (*Anthistiria gigantea* Cav. subsp. *arundinaceae* Hack. F.B.I. 217).

Themeda caudata (Nees) Dur. et Jack. (*Anthistiria gigantea* Cav. subsp. *caudata* Hack. F.B.I. 217).

Themeda longispatha (Hack.) Raizada and Jain status nov. (*Anthistiria gigantea* Cav. subsp. *caudata* var. *longispatha* Hack. F.B.I. 217).

Themeda anathera (Nees) Hack. (*Anthistiria anathera* Nees ex Royle F.B.I. 215).

Themeda villosa (Poir.) Dur. et Jack. (*Anthistiria gigantea* Cav. subsp. *villosa* Hack F.B.I. 217).

ISEILEMA Anderss.

Iseilema anthephoroides Hack. (F.B.I. 219).

Iseilema laxum Hack. (F.B.I. 218).

Iseilema prostratum (Linn.) Anders. (*Iseilema wightii* Anders. F.B.I. 218).

HETEROPOGON Pers.

Heteropogon contortus (Linn.) Beauv. ex R. & S. (*Andropogon contortus* Linn. F.B.I. 999).
Heteropogon melanocarpus (Muhl.) Benth. (*Andropogon melanocarpus* Elle. F.B.I. 200).

Tribe III. *Maydeae*

ZEA Linn.

**Zea mays* Linn. (F.B.I. 102).

COIX Linn.

Coix lachryma-jobi Linn. (F.B.I. 100 excl. vars.).
Coix gigantea Roxb. (*Coix lachryma-jobi* Linn. var. *gignatea* Stapf F.B.I. 100).

CHIONACHNE R. Br.

Chionachne koenigii (Spr.) Thw. (*Polytoca barbata* Stapf F.B.I. 102).

* An asterisk in front of a name means that the particular species has been introduced.

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COMPARATIVE STUDY OF INDIAN AND AMERICAN PLYWOOD SHEAR TEST STANDARDS

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SUMMARY

The standard specimens used in finding out the shear-strength of the glue joints should have the saw cuts half an inch apart when the face plies are 0·047 inch or less in thickness, and the saw cuts should penetrate two-thirds through the core. This is to avoid the breaking of face plies at the saw cut and to get the real shear strength value of the glue bond.

INTRODUCTION

The "Tentative Indian Standard Specification for Plywood Tea-Chests" IS : 10–1949, and the "Indian Specification for Commercial and Moisture-proof Plywood (Tentative)" IS 303–1951, were issued by the Indian Standards Institution, whereas the Specification No. IND/G.S/527 (C) for "Plywood Marine" was issued by the Ministry of Defence. All these specifications do not describe the specimens used for shear test, to test the quality of glue joint of plywoods whose face plies are 0·047 inch or less in thickness or are made out of a wood of lesser strength. The American Standard Specifications do prescribe two different dimensions of shear areas for finding out the shear-strength of plywoods, depending upon the thickness of the face plies. The object of this article is to compare the prescribed American and Indian Standards of testing of plywoods for shear-strength and to find out which of the standards would suit for testing plywoods whose face plies are 0·047 inch or less in thickness.

MATERIAL

The required material was supplied by the Mysore Commercial Union, Yeswantapur. It consisted of two kinds of plywoods of mango (*Mangifera* Sp.) and *dhupa* (*Vateria indica*) of thickness 2·3 mm. and 2·0 mm. respectively and both of them were of 3 ply. Since the total thickness of the plywoods of both kinds was 2·3 mm. or less, the face veneers in each kind was less than 0·047 inch in thickness.

METHOD

The following procedure was adopted in preparing shear test specimens from plywood boards of Mango and *Dhupa.*

Mango plywood—Strips of 6″ × 1″ were marked on the plywood along the grain and named 'A', 'B' and 'C' consecutively and then the same was repeated. To all the strips marked 'A' saw cuts were made one inch apart with a shear area of one square inch (Text Fig. 1) and for the specimens marked 'B' (Text Fig. 3) and 'C' (Text Fig. 3) the saw cuts made were half an inch apart with a shear area of half square inch. The saw cuts made for 'A' and 'B' groups penetrated completely through the core (Test Fig. 1), whereas for 'C' the saw cuts penetrated through two-thirds the core (Text. Fig. 3).

Dhupa plywood—On the *Dhupa* plywood board strips of 6″ × 1″were marked as in the previous case and marked 'D', 'E', 'F' and 'G' consecutively and repeated. The saw cuts in groups 'D' and 'E' were situated one inch apart and in 'F' and 'G' half an inch apart.

In all the samples of groups 'D' and 'F' saw cuts penetrated completely through the core, whereas in case of 'E' and 'G' only two-thirds through the core.

Unfortunately as the saw cuts were not properly made in some of the specimens of groups 'F' and 'G' several of them had to be rejected.

An universal timber testing machine of German make was made use of in testing all the specimens for dry shear test.

OBSERVATIONS

The results obtained by testing mango and *dhupa* plywood specimens of groups A, B, C, D, E, F and G are noted in Tables 1, 2, 3, 4, 5, 6 and 7 respectively. Table 8 gives the consolidated and average figures of Tables 1 to 7.

TABLE 1

Shear-strength of mango-plywood specimens with saw cuts one inch apart and completely cut through core

Shear-strength in PSI	Per cent wood failure	Per cent failure at or near the glue line
156	100	0
167	100	0
268	100	0
224	100	10
139	100	0
154	100	0
158	100	0
211	100	0
229	100	0
141	100	0

TABLE 2

Shear-strength of mango plywood specimens with saw cuts half an inch apart and completely cut through core

Shear-strength in PSI	Per cent wood failure	Per cent failure at or near the glue line
308	100	60
233·2	100	0
321·2	100	0
158·4	100	0
193·6	100	10
224·4	100	60
242·0	100	35
268·4	100	0
264·0	100	0
184·8	100	0

TABLE 3

Shear-strength of mango plywood specimens with saw cuts half an inch apart and two-thirds cut through core

Shear-strength in PSI	Per cent wood failure	Per cent failure at or near the glue line
308·0	100	35
352·0	100	60
321·2	100	30
224·4	100	0
202·4	100	30
242·0	100	55
211·2	100	30
290·4	100	40
492·8	100	85
286·0	100	60

TABLE 4

Shear-strength of dhupa plywood specimens with saw cuts one inch apart and completely cut through core

Shear-strength in PSI	Per cent wood failure	Per cent failure at or near the glue line
165	100	0
128	100	0
326	100	5
123	100	5
84	100	5
167	100	0
97	100	0
271	100	10
213	100	0
352	100	10
227	100	0
211	100	10
411	100	5
264	100	5
345	100	5

TABLE 5

Shear-strength of dhupa plywood specimens with saw cuts one inch apart and two-thirds cut through core

Shear-strength in PSI	Per cent wood failure	Per cent failure at or near the glue line
398	100	5
220	100	10
262	100	5
257	100	5
354	100	0
275	100	20
268	100	15
326	100	5
323	100	20
279	100	10
381	100	15
407	100	30

TABLE 6

Shear-strength of dhupa plywood specimens with saw cuts half an inch apart and completely cut through core

Shear-strength in PSI	Per cent wood failure	Per cent failure at or near the glue line
250	100	100
396	100	100
382	100	60
260	100	100
312	100	100

TABLE 7

Shear-strength of dhupa plywood specimens with saw cuts half an inch apart and two-thirds cut through core

Shear-strength in PSI	Per cent wood failure	Per cent failure at or near the glue line
228	100	100
304	100	100
414	100	100
462	100	70
308	100	100

TABLE 8

Average shear-strength and average per cent of failure at or near the glue line and other details for groups A to G (Tables 1 to 7)

Kind of Plywood	Group	No. of specimens tested in each group	Average shear strength in PSI	Average per cent wood failure	Average per cent of failure at or near the glue line	No. of specimens actually broken at Saw cut
Mango	A	10	185	100	1	9
,,	B	10	240	100	16·5	6
,,	C	10	264	100	42·5	1
Dhupa	D	15	227	100	4·0	5
,,	E	12	313	100	11·7	1
,,	F	5	320	100	92·0	0
,,	G	5	309	100	94·0	0

SHEAR AREA AS PER INDIAN STANDARD

The "Indian Standard Specification for Commercial and Moisture-proof Plywood (Tentative)" IS 303–1951 (Text Fig. 1) and the "Tentative Indian Standard Specification for plywood Tea-chests" IS 10–1949 recommend that the saw cuts made should be one inch apart in each shear test specimen, while the "Specification No. IND/GS 527(C) for Plywood Marine" advocates that the distance between the two saw cuts should be either one inch or eight times the thickness whichever is smaller. For all specimens the saw cut made, penetrates completely through core (Text Fig. 1).

SHEAR AREA AS PER AMERICAN STANDARD

The American Standard Specification for plywood shear tests prescribe that the saw cuts should be one inch apart in case of plywoods having thicker faces than 0·047 inch, and half an inch apart in case of plywoods whose faces are 0·047 inch or less in thickness. The saw cuts made, go only two-thirds through the thickness of the core irrespective of the thickness of the face plies.

DISCUSSION

It may be seen from Table 1 that nine out of the ten mango plywood specimens (Group A), and from Table 4 that five out of the fifteen *dhupa* plywood specimens (Group D) broke at the saw cut region, thereby showing that the face plies which were less than 0·047 inch in thickness broke before the load applied could bring about failure of the glue bond, in the shear area of one square inch. In both cases of 'A' and 'D' group of specimens the average per cent of wood failure at or near the glue line are 1 and 4 respectively, showing that the required failure did not occur at the glue bond. Out of twelve specimens of group E (Table 5), only one specimen broke at the region of the saw cut. There is of course improvement over specimens of group 'D' but it is not satisfactory as the average per cent of failure at or near the glue line is only 11·7.

Specimens of groups 'B' and 'C' are improvements over specimens of group 'A'. But the superiority of specimens of group 'C' over 'B' is only attributable to the difference in the depth of saw cut. Group 'B' had the saw cuts which penetrated completely through the core (Indian Standard), whereas, in case of 'C' they penetrated only two-thirds through the core (American Standard). This difference has brought about phenomenal results in 'C'. Only one out of ten specimens of 'C' has failed at the region of saw cuts, whereas six out of ten specimens of 'B' have broken at the region of saw cuts. Furthermore, in specimens of group 'C' 26 per cent more of failure at or near the glue line has taken place than those of group 'B'. The average shear value of group 'C' is slightly higher than that of group 'B' and considerably higher than that of group 'A'.

As in case of specimens of group 'C' the specimens of 'G' give superior results to groups 'D', 'E' and 'F' atleast as far as the per cent of failure at or near the glue line are concerned. The superiority of specimens of 'G' over 'F' is not well brought out due to the fact that only five specimens were tested.

It is clear from the experiments that the thickness of face plies is an important factor to be taken into account in determining the shear area for specimens used for shear tests. An uniform shear area of one square inch does not hold good for all plywoods. The distance between the saw cuts should be determined according to the thickness of face plies; it also depends on the strength of wood used for face plies, though no experiment pertaining to this has been stated here. In case of plywoods whose face plies are thin it is evident from the tests described here that the saw cuts should not be made one inch apart or eight times the thickness as specified by the Indian Standard. By making the saw cuts according to the Indian Standard the failure takes place invariably not at any of the glue joints but at one of the saw cut regions (Plate I specimens 1 and 2, 7 and 8). Thus while the purpose of the test is to find out the shear-strength of the glue joint, by making the saw cuts one inch apart, actually the tensile strength of one of the face plies is determined.

To over come this flaw the American Standard specification for plywood testing recommends that the saw cuts should be one inch apart in case of plywoods having thicker faces than 0·047 inch, and half an inch apart in case of plywoods, whose faces are 0·047 inch or less in thickness (Text Fig. 2 and 3). By reducing the shear area as in the latter case (Text Fig. 3) naturally the load to cause failure is reduced and it is generally not sufficient to break the face plies at one of the saw cut regions and, therefore, it facilitates the failure to occur at one of the glue joints. (Plate I, specimens 5, 6 and 12).

When the shear area used for shear test is one half of one square inch, in order to obtain the shear-strength per square inch, the value got is doubled and ten per cent deducted from it. By adopting half a square inch as shear area for plywoods whose face plies are thinner, the preparation of test specimens and the calculations are rendered easy.

The depth of saw cuts in plywood specimens meant for shear test is as important as the shear area. The difference in the depth of saw cut between the Indian and American Standards has already been mentioned and its effect on the results may be seen from Table 8. The outstanding advantage in adopting the American Standard type of specimens is, that when the specimens are subjected to shear stress, the breaking of one of the face plies does not usually take place at the saw cut region, but on the other hand it generally takes place at the glue line (Plate I specimens 6 and 12), which is very essential in such tests. This is confirmed from Tables 3 and 7.

CONCLUSION

As regards the distance between the saw cuts and depth of saw cuts of plywood shear test specimens are concerned, it is found better from the experiments conducted to adopt American Standard Specifications.

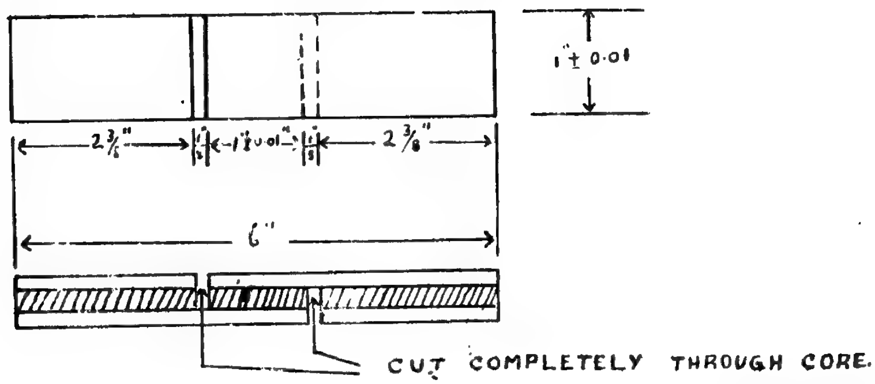


FIG. 1.

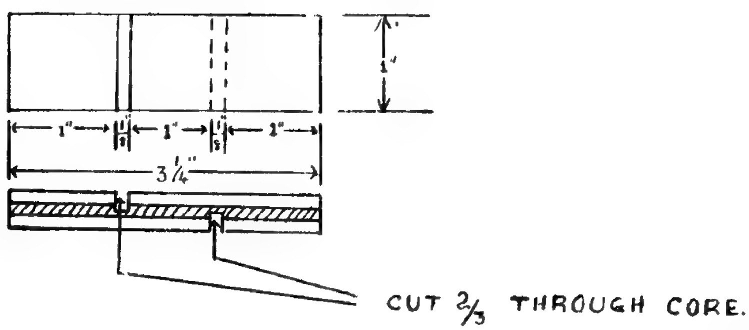


FIG. 2

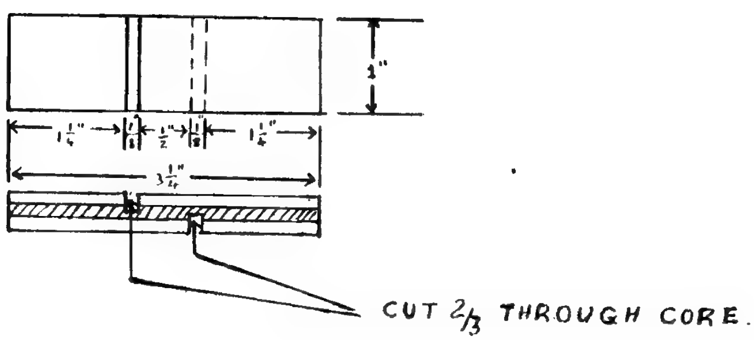
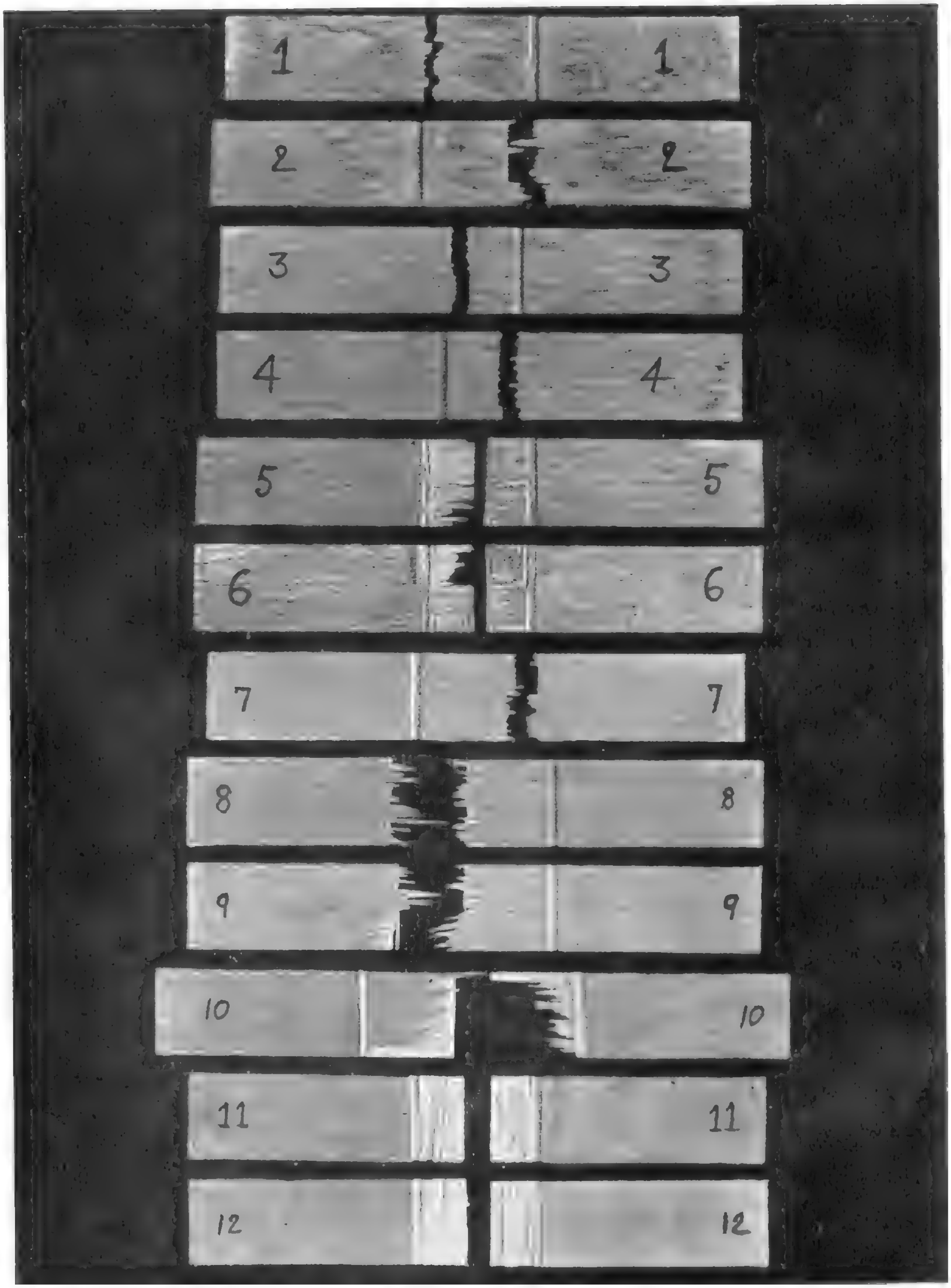


FIG. 3.

PLATE I.



For plywoods whose face plies are thicker than 0·047 inch the shear area should be one square inch, and for those whose face plies are 0·047 inch or less in thickness, it should be half a square inch, and the saw cuts should penetrate only two-thirds through the core for both the kinds. The limitation of 0·047 inch thickneess of face plies stated above may be tentatively adopted till further work is done on this.

ACKNOWLEDGMENTS

The writer is grateful to Shri M. A. Muthanna, B.SC., I.F.S. (DIP.), Chief Conservator of Forests in Mysore, Bangalore, for his valuable suggestions and encouragement in completing this article.

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EXPLANATION OF TEXT FIGURES AND PLATE

Text Fig. 1. Plywood shear test specimen (Indian Standard) 5/12 the actual size.

Text Fig. 2. Plywood shear test specimen (American Standard) with one square inch shear area, ½ the actual size.

Text Fig. 3. Same as in Figure 1, but with half square inch shear area.

PLATE I

Specimens 1–6 Mango plywood
- 1 & 2 Group 'A' – Failure at the region of saw cut.
- 3 & 4 Group 'B' – Failure at the region of saw cut.
- 5 & 6 Group 'C' – Failure at or near the glue line region.

7 to 12 *Dhupa* plywood
- 7 & 8 Group 'D' – Failure at saw cut region.
- 9 & 10 Group 'E' – Failure partially at the glue line region.
- 11 Group 'F' – Failure at the glue line region.
- 12 Group 'G' – Failure at the glue line region.

The counterparts of 5, 6, 10, 11 and 12 have been turned over to show the fracture at or near the glue line.

FORESTRY IN LAND RECLAMATION

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A well kept forest is nature's best soil holder and is nature's great water reservoir. On bare ground especially on steep slopes, water flows down uninterrupted carrying much of the soil with it. Forests hold back more rain and water and more soil on the steep slopes than denuded woodland or overgrazed pasture.

There are three main objectives for tackling the unproductive land problem through the agency of forestation :—

1. Timber production.
2. Water-shed protection.
3. To avoid misuse of land.

The area which can and should be used for forestry—Out of a total of 4·4 million acres of land in Damodar catchment at the junction of Damodar and Barakar, nearly 1·5 million acres is under forest and about 1 million acres is under wastelands.

The wastelands, the cultivated uplands and gullied jungles are the main sources of silt transport and need protection from erosion most. Out of the wastelands some of the gullies need to be reclaimed for forest and some for paddy and some uplands for pasture and forest.

It is true that at present some of the forest areas have little potential value for timber production but most of these areas have considerable economic value for protection of water-shed, as pasture for live-stock and as a source of fuel wood, fence posts, etc. Land used for upland agriculture has been showing a net decrease. Abandonment of some lands is being off-set by clearing and cultivation of others.

Some of the idle or fallow crop-land, at present classified as crop-land and pasture, is essentially sub-marginal in character, and will be available for forestry. All of this if planted will support some kind of tree growth and distinct social and economic advantage may result from devoting it to forestry.

Some of the gullied areas and some of the wastelands will be available for afforestation. In the procedure of soil mapping of waste and unproductive lands for reclamation purposes in the Damodar Valley, a method of soil mapping has been evolved which takes into consideration the following major and minor soil characteristics – (1) the effective depth of the soil, (2) surface and sub-surface (15–18″ depth) soil texture, (3) Permeability, (4) Erosion, (5) Soil reaction, (6) Phase.

The effective depth classes mapped for reclamation purposes are 0–1′, 1–2′, 2–3′, 3–5′ and over 5′ with gullied, hummocky and miscellaneous areas and rock out crops shown by separate notation. Lands up to 3% slopes are being reclaimed into paddy and upland fields according to depth and textural condition, whereas the soils with depths varying from 0–1′ and in some cases 1–2′ have been left out for afforestation irrespective of their slopes.

Area under forest land use—In the past forest areas have been used for agriculture but have lost their fertility through either misuse or erosion. Forest growth on these areas will restore the organic matter content of the soil and improve its physical condition so that in future it may again support profitable agriculture.

These sub-marginal abandoned areas have been so badly eroded that such engineering practices as terracing and contour ditching are not enough to check the erosion menace. Such areas must be put under permanent forests.

Reclamation of badly gullied and exposed areas by forestry—Trees and forest are very useful tools of soil conservation programme. Planted trees can restore to productivity eroded areas lost to most other useful purposes. Forest conserves the nutrients and maintains good soil structure. We should evolve a cropping system that does make periodic use of forests for regeneration of soils for cropping. Forests shade the soils and keep it cool, maintain structure and conserve nutrients against strong forces of leaching. Properly managed and protected forests afford the best protection to soils. It will be futile for Soil Conservation Department to attempt to plant trees on land unfit for other purposes if it does not at the same time take care of existing forests on the lands best suited for trees. Tree planting and woodland management are, therefore, integral part of soil conservation.

The message about trees and how they fit into farming to conserve soil and help farmers make a better living is carried by soil conservationists in the United States of America. This is a part of the land use adjustment involved in farm planning.

Gullies are the end result of various forms of land abuse. In the early stages effects of run-off may be arrested by limited reforestation, simple dams and inexpensive measures. The progress of gully erosion proceeds at an extremely rapid rate and in the course of few years its control may become a serious problem for both foresters and engineers.

The choice of species used in planting gullies and surrounding areas is influenced mainly by their ability to control erosion.

The selection of species depends upon soil reaction, moisture condition and other factors. Forest planting can be supplemented by the seeding of eroded gully banks to grasses. Gullies in an acute state of erosion may require engineering work prior to afforestation.

Afforestation for water-shed protection—The establishment of a forest cover on eroding areas by afforestation is an effective means of controlling erosion. Gullies planted to *Acacia* and certain legumes can become stabilised within a period of few years following planting. Forest cover exerts its control over erosion in a number of ways. Litter and the organic cover on the soil in the forests prevents washing of surface. It adds organic matter to soil, makes it porous and receptive to the percolation of water.

This reduces surface run-off and retards the erosive action of such surface run-off as may occur. Large areas of eroded lands not capable of producing other worthwhile crops are suitable to forest growth and once the forest is established the erosion cure is permanent provided reasonable protection and management is given.

Afforestation of barren and unproductive lands—A part of the solution lies in the reclamation of such land through forest planting. No other practical measure will restore a large part of these lands to usefulness within a reasonable period.

These are some thousands of acres of abandoned forest land in the valley, so badly eroded that successful agriculture is impossible. The exposed subsoil is incapable of producing satisfactory yields of farm crops and is suceptible to further erosion. It will, however, support tree growth and can eventually be successfully forested by planting.

Critically eroded areas which might ultimately restock naturally but where reforestation is not taking place rapidly enough to afford timely protection should be planted. Erosion on critical areas is now going on at such an accentuated rate that immediate action is justified to stop the sluicing of soil in the stream channels.

Abandoned agricultural land contributes largely to erosion problems and it offers greater opportunities for forestry returns than the poorer classes of forest lands. Although depreciated in forestry from an agricultural stand point abandoned agricultural land is usually more fertile than the average devastated forest site and is usually more accessible.

We in Damodar Valley in our soil mapping for reclamation purposes delineate such denuded and unproductive lands varying in depth from 0–1′ on 16″ to a mile village maps, and after proper contour survey at $2\frac{1}{2}$–5′ vertical interval recommend contour trenching and put such areas under afforestation. To save the contour ditches from early filling up quick growing grasses and shrubs are grown on the side slopes after proper dressing up of the slopes. The intervening areas between the contour trenches are planted to pasture grasses or some crops according to the suitability of the areas. The areas are fenced from live-stock and planted with different leguminous and non-leguminous trees. The following species are suggested for planting for various uses of the villagers :—

(*a*) For Timber

1. *Acacia arabica*
2. *Dalbergia sissoo*
3. *Terminalia arjuna*
4. *Artocarpus integrifolia*
5. *Shorea robusta*
6. *Melia indica*
7. *Terminalia tomentosa.*

(*b*) For Firewood

1. *Acacia moniliformis*
2. *Pongamia glabra*
3. *Cassia siamea*
4. *Tamarindus indica.*

(*c*) For Green manure

1. *Pongamia glabra*
2. *Delonix regia*
3. *Sesbania grandiflora*
4. *Sesbania falcata*
5. *S. macrocarpa*
6. *Gliricidia maculata.*

(*d*) For Fodder

1. *Dalbergia sissoo*
2. *Acacia arabica*
3. *Artocarpus integrifolia*
4. *Ficus bengalensis*
5. *F. religiosa*
6. *F. glomerata*
7. *Sesbania grandiflora*
8. *Enterolobium saman.*

To give the seedlings a better start, fertilizer an oz. or so of Ammonium Sulphate and Super Phosphate can be given. The contour trenches are safely diverted to either a graded channel down the slope or to a pond below, as the case may be.

In Damodar Valley region, where moisture is available for seedlings only for very short periods we have to resort to moisture conservation practices. One of the most efficient practices of moisture conservation is to have trenches along the contour at intervals depending on soil slope and rainfall.

In high intensive rainfall areas, trenches with gentle slope grades 1 in 200 to 1–500 can be tried. These graded channels can be interrupted by undug soil blocks with temporary protected outlets for spillovers.

Sometimes diversion dykes or channels have to be resorted to and concentrated flow diverted to less vulnerable places of discharge.

Afforestation of rock out crop areas—The process of erosion in places has exposed the bed rock. This is especially common in regions of calcareous formations. To get vegetation cover on such denuded areas is a difficult task. Afforestation of such rocky areas can be accomplished. Trenches can be excavated in rocks to receive the soil and seedling. Strong transplants should be used in afforestation of such sites.

Along with actual planting must go comprehensive land classification and Land Use Planning to assist in the selection of lands which should be permanently removed from agricultural use either because of their sub-marginal character or because of the probability that continued cultivation would destroy their value through erosion. Land classification surveys are the basis for the best fundamental land use adjustment. Their objective is systematic land use planning based upon the intensive physical, economic and social studies of individual regions. They are an attempt in a systematic way and after intensive study of factors affecting land use and occupancy, to assign each area to that use to which it is best adapted physically, economically and socially. Physical classification of lands is necessary step to systematic land use planning, since without a physical inventory of available lands and classification of possible uses there is no basis upon which to plan.

The paper recommends the tool of afforestation and reforestation for reclaiming the barren or unproductive lands and denuded forests in the valley which are sub-marginal in their productivity for agricultural purposes. The author feels that the extension service can do a lot to extend the programme of forestry for the benefit of the community. Forest Department can assist in this work by growing and distribution of tree planting stock. In our Five-Year community project scheme, there should have been included a Forest Officer in the team to advise farmers regarding the establishment, protection (against fire and overgrazing), and management of farm forests (Woodlots).

INTERESTING FOOD OF THE MURIAS

BY S. D. N. TIWARI, F.B.S., S.F.S.

In the month of January and February one can see in Bastar, aboriginals digging out something in the forest generally in the afternoon. On enquiry, a new-comer to the district is surprised to find in their little bamboo baskets carefully lined by *sal* leaves, about a dozen of white fat larvae about $1\frac{1}{2}''$ long $\times$ $\frac{3}{4}''$ collected from the bulbs of small plants for their evening meals. These larvae are fried in *Mohwa* oil and are eaten in between the gulps of their liquid rice diet (known as *paje*). Some Officers report that in the *Mar-land* which is very much secluded from civilization, the *Madias* eat them raw sometimes. From January to April they are also available in markets.

These larvae bore the main shoot of Chhind (*Phoenix acaulis*) and enter its bulbous ground stem. (Picture 1). There is only one larva per plant.

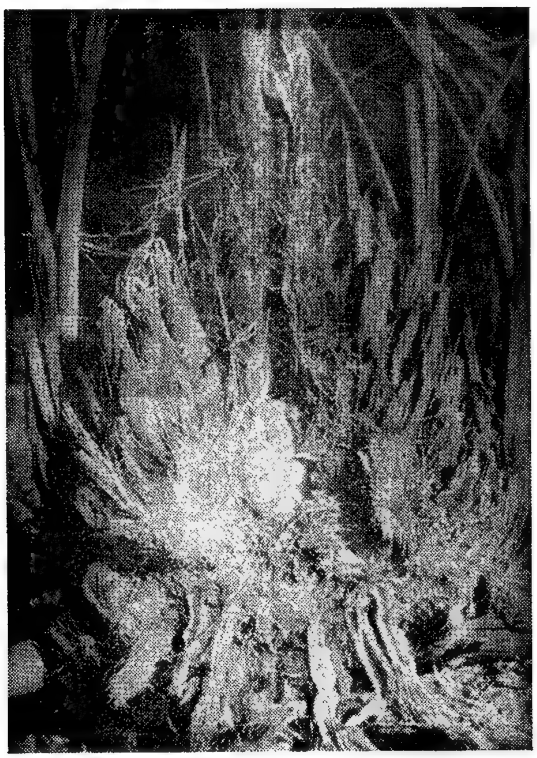

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PHOTO 1

A longitudinal section through the Chhind bulbs showing the tunnel bored through the centre of the stem and the larva in situ at the bottom of it.

Photo by author.

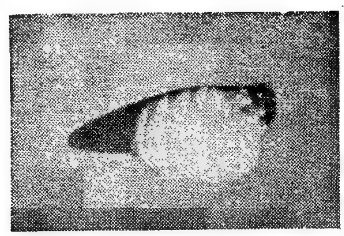

PHOTO 2

The larva $\times$ $\frac{1}{2}$ natural size.

They are about 1″ long in January and about 2″ in March to April (Photo No. 2). When they are mostly eaten. Later, they generally enter into the quiescent stage and turn little brownish. They are not very much liked at this stage. No chitin or pupa was seen round them even till the end of June. A few Chhind bulbs were sent to Forest Research Institute for identification of the borer and they have given its generic name as *Protocerius* sp. The larvae in the Chhind bulbs sent to them died and they could not get the adult specimen and thus are unable to give its specific name. However, the name matters little. I had kept

some Chhind bulbs dug out in June for observation. On cutting out the bulbs in August, only a dead shrivelled larva was found. But from the description of the aboriginals it appears that the adults emerge out sometime in July–August and they are reddish in colour. Till now I have been unable to catch the adults. The probable time when the eggs are laid is October to November. The plant attacked generally dies out by next year.

Many thoughts rushed through my mind when I saw these pearly white borers. It was the time when symposium to discuss the problems of *sal* regeneration was to be held and I thought this is a good instrument to wipe out the dense Chhind which stops the *sal* seeds from reaching the ground. Secondly, they could provide an additional source of tasty and clean food coming out from the white sweet bulbs, which could also be canned, exported and advertised as Bastar novelty. However, I thought it better to consult my Muria friend. He threw cold water on my schemes. He told me that Chhind is one of the most important plants to them. Its leaves are used to line all the interior of the thatched roof of the huts specially as bamboos are not available in the locality. Its bulbs are eaten as vegetable and its fruit are relished by them. It keeps down the tall growth of grass and shrubs and is resistant to fires with the result that the wild fires generally terminate near the dense Chhind patch. If the leaves are cut before the seed-fall, the *sal* seeds reach the ground and easily germinate under it and grow well. Actually good *sal* saplings are only seen among Chhind patches in Bastar.

In all such delicate matters I have always relied on the verdict of the local people. Here also, I think that it is better to leave the nature to balance itself and the Murias to get their extra ration from these Chhind bulbs.

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FOREST DEVELOPMENT OF ANDHRA STATE

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The Andhra State as formed contains roughly 17·8% of its total land area under *Reserved forests* according to the official figures of 1945–46. This area does not include some of the *Panchayat* managed forests which have since reverted to the Forest Department nor the private forests of *zamindaris* which are now vested in the State. It is believed that when the *zamin* forests are duly examined and are constituted into Reserved forests, roughly about 23% of the land area may be under forests. This is satisfactory so far as it goes, but considering the mal-distribution of the forests and the poor rainfall occurring in most of the tracts, more land has to be brought under forest vegetation, to alleviate the distress due to frequent droughts and famines in the Rayalaseema and to meet the legitimate demand of the public regarding firewood, small timber, grazing and fodder. This problem has to be approached in three ways : firstly by the rehabilitation of existing forests and secondly by afforestation on a large scale and thirdly by extensive adoption of farm-forestry methods, by which each *raiyat's* farm or holding will become self-sufficient regarding its requirement of fuel and small timber, besides deriving the indirect benefits of tree growth in them.

Rehabilitation of the Forests—Most of the forests of Andhra desa especially those which occur in Rayalaseema have suffered much from the hand of man. Over exploitation and frequent burning of the forests have had their baneful effect on the tree growth and many so-called Reserved forests are very open. The *panchayat* forests which have now become bare on account of unbridled enjoyment by the public in the past, requires rest from further exploitation and careful rehabilitation. This can be achieved only if enlightened public opinion strengthens the hands of the Forest Department. It is significant that in the famine zone of Rayalaseema comprising portions of Anantapur, Kurnool and Bellary districts, not only the total extent under forests is poor, about 5 to 10%, but the forests themselves were under popular management by *panchayats*. There the forest department has inherited bare reserved forests devoid of tree growth and containing coarse grass. A few years protection of these forests has demonstrated that even these forests can be rehabilitated provided rest from felling and controlled grazing are achieved. Certain amount of popular opposition does exist to any restriction of the previous enjoyment but this has to be overcome by propaganda, patience, and firmness, in the larger interests of the newly formed State. Merely by giving rest, it may not be possible to achieve completely the main objective. Artificial regeneration methods, which adopt moisture conservation practices like *rab* regeneration, *kumri*, trench and ridge sowings, Tummala method (ridge and cross ridges), etc., have given very good results. These methods will no doubt cost some money but they may have to be adopted if famine conditions have to be averted. Reserved forests which require to be regenerated have to be carefully examined and plans drawn up for their speedy rehabilitation.

The second method of approach is by afforestation on a large scale in lands at the disposal of Government. Such lands should be brought under correct management, after a land capability survey. Lands which have to be under permanent tree growth according to that survey, should be speedily afforested. Such a step will not only increase the area under forests, but also conserve soil and moisture in the tract.

The third method of approach is very important. The *raiyat* in his holding must raise suitable trees as a wind break not only to protect his valuable fields from wind erosion, but to provide him with fuel and small timber as well. This is called farm-forestry. If each farm is self-sufficient regarding its forest requirements the reserved forests will be safe from fellings to that extent. Further these farm-forests will conserve moisture and soil in the farm and if such a practice were to catch the imagination of the *raiyats* residing in the famine tracts, famine conditions may not recur and to that extent, the infant state will be saved considerable expenditure on famine works.

Areas of high rainfall are highly limited in the Andhra State. The Rayalaseema, but for portions of Nallamalais, generally receives less than 30 inches rainfall. It is not realized sufficiently by people of the tract that trees in such areas grow slowly and rehabilitation of forest growth is ever so much difficult and requires much patience and co-operation from the people. Countless large scale experiments have proved that it will be possible to afforest areas even in tracts of poor rainfall at reasonable costs. Also nature has grown first class species like teak, red sanders, *Hardwickia binata*, *Pterocarpus marsupium*, *Chloroxylon swietenia*, even in these poor rainfall areas. So their regeneration will not offer much of a problem.

All that is now necessary is to organize the work on a planned basis. Since growing of trees on a large scale is the principal method of rehabilitation no doubt the major portion of the work will devolve on forest officers. In this context it will be a progressive step for the new state if a Land Development Department to rehabilitate lands outside Reserved forests is created under the head of an experienced forest officer who has knowledge and experience of the tract and its people and its problems. This department can also look after soil and water conservation measures of the new State.

Development of existing forests—The next problem which will confront the new State will be the development of its existing forests. The principal forest tracts of Andhra desa lie in the agency tracts of Visakapatnam and Godavari districts and in the Nallamalais and its extension to the south called the Palkondas and Seshachallams, the latter ending near Tirupathi in a bold escarpment. Velikondas separating Nellore and Guntur districts from the Cuddapah and Kurnool districts, also contain patches of good tree growth. The first step to be taken to develop these forests will be to open out the tract by a net work of roads to facilitate their economic working. The agency forests and the Nallamalais contain enormous quantities of bamboos crying for exploitation. If these are exploited and treated, plentiful supply of "poorman's timber" namely the bamboo will become available to the public at economic rates. Also additional quantities will become available for starting paper factories, especially in the Nallamalais.

Apart from bamboo, considerable quantities of pole forests of good timber species will then come within the economic reach of timber markets. In the agency forests of Visakhapatnam, especially in portions of Palakonda, Sanivaram, and Gundem ranges, pole forests of *Terminalia tomentosa*, *Pterocarpus marsupium*, *Xylia xylocarpa*, *Anogeissus latifolia*, *Chloroxylon swietenia*, *Cleistanthus collinus* and *Adina cordifolia* occur. East Godavari agency forests in addition contain teak, *Soymida febrifuga*, *Lagerstroemia* spp., *Schleichera trijuga*

and *Terminalia tomentosa*. It is certain that the pole growth of many of these species can be used after suitable treatment in building practices. This possibility deserves investigation.

In the Nallamalais increased quantities of *Hardwickia binata*, *Pterocarpus marsupium*, Teak, *Terminalia* sp., poles can be made available if the tract is opened out for exploitation. In view of Kurnool having been chosen as the temporary Headquarters of New Andhra State, the possibility of increased exploitation of Nallamalais has to be investigated. In this tract and in the adjacent Yerramalais, *Boswellia serrata* and *Dolichandrone crispa* pole crops also occur. These also can be exploited in increased quantities.

In the Lankamalais, Palkondas and Seshachallams of the Cuddapah districts considerable quantities of pole crops of red sanders, *Hardwickia binata*, *Chloroxylon swietenia*, *Anogeissus latifolia*, *Dolichandrone crispa*, *Soymida febrifuga*, are available. Closer exploitation of these species are indicated, after opening out the country especially the plateau regions. At present for want of exploitation facilities some of the interior forest coupes are neither sold at all or sold at nominal prices, principally for firewood.

Generally above 2,000 feet elevation in the Seshachallams near Tirumalai konda on the high level plateaux an *Eugenia-Shorea* type of forest occurs. In a typical forest belonging to this type, *Eugenia alternifolia* (*Mogi*) forms nearly 80% of the crop. *Shorea tumbaggaia* is practically confined to the hillocks and ridges on the plateau while, *Shorea talura* confines itself to stream banks. *Buchanania latifolia* and *Terminalias*, especially *Terminalia pallida* also occurs. *Eugenia* and *Terminalias* occupy about 55,000 acres of compact region in this locality. At present this growth is not being exploited. The possibility of marketing these species, if necessary after treatment may have to be investigated.

Casuarina plantations—So much about natural forest growth and its development. Next the development of *Casuarina* plantations has to be considered. *Casuarina equisetifolia* plantations have been raised all along the coastal regions of Andhra desa. At present this species is being sold principally as firewood. To a small extent it is used as poles. In a country where timber supply is none too plentiful the possibility of utilizing this species as timber, has to be considered, may be after treatment with suitable preservatives. Most of the *Casuarina* plantations are worked on short rotations. The possibility of growing some on a larger rotation in special localities may have to be considered. *Casuarina* is capable of being grown to timber sizes even on comparatively short rotation. As *Casuarina* plantations are first rate commercial propositions private enterprise has taken to raising them. First step to be taken will be to delimit all coastal areas not utilized for agriculture or other plantation crops like cocoanut, etc., and raise on them *Casuarina* or other suitable species. The possibility of growing Teak in such areas may have to be seriously considered. This is one of the quickest methods of developing the forest wealth of Andhra desa.

Foreshores of tanks—There are many tanks especially in Rayalaseema and in the up lands of Nellore, Guntur, Krishna and Godavari districts. The foreshores of these tanks are excellent from the point of view of growing useful trees, as they contain moisture for a long period in the year. The natural species of these foreshores is *babul* (*Acacia arabica* – *Nallathumma*), a very useful multipurpose tree. But as these foreshores are not under any enlightened management they are not fully utilized, or correctly managed. If these foreshores are managed correctly they will make important contributions to local fuel and small timber economy and to that extent relieve the demand on the reserved forests. This work may be entrused to the Land Development Department suggested earlier.

Road-side avenue planting—In common with the residuary Madras State, avenue planting is another neglected activity in Andhra desa. Systematic planting and exploitation

of avenue trees should be undertaken by the State. This work is done in U.P. and in Punjab by the forest department and can very well be entrusted in Andhra desa to the proposed Land Development Department.

Forest development in river valley project areas—The popular opinion is that forests should depend only on natural rainfall for their development. Gradually the opinion is changing and the public do not mind watering *Casuarina* plantations during summer, till the *Casuarina* growth gets established. The possibility of raising irrigated plantations of valuable species like Teak, etc., has never been seriously considered, though in Punjab even in the last century, irrigated firewood plantations of *Sissu* had been raised. In Andhra desa, Rama pada Sagar and Krishna and Pennar Projects are under consideration. Even now there exists many irrigation projects in the Andhra desa with their net work of canals. The possibility of allotting some water from these projects for raising irrigated plantations of bamboo, teak and other valuable timber species has to be seriously considered. One cusec for eight months, worked on a duty of 120 acres will mean an equivalent of about 48 inches rainfall. With this addition to local coastal annual rainfall it will be possible to grow Teak into timber sizes within a reasonable period. Also canal banks and adjacent strips of land, are localities where excess of moisture will be available on account of seepage. There are many miles of such strips available even at present. These have to be examined carefully and the possibility of raising timber species useful for wood based industries and also bamboos will have to be investigated.

Also in the River Valley Project areas, as a result of the project the sub-soil water level in many places will rise up. Through this may not be economic for raising agricultural crops by lift irrigation, they will be ideal for raising timber plantations of valuable species. Such lands must be dedicated to growing trees of valuable species, as extension of wet cultivation will mean increased demand for timber.

Development of forest grazing and fodder—Forest development of Andhra desa will not be complete unless forest grazing also is developed side by side. Andhra desa has the unique distinction of possessing a world famous breed of dual purpose animal, the ongole breed of cows and bulls. This breed thrives primarily on *Isielema laxum* (*Chengali gaddi*). During the rainy season these cattle are sent to the forests of Rayalaseema for grazing either on account of the tract being extensively cultivated or to give the grass in the local *Kanchas* time to grow. The *Kancha* system of Nellore is a very ancient system of giving rest to the pasture lands during the growing season, to give an opportunity for the grasses to grow. After the grass has developed in the *Kancha*, the grazing is restricted to the capacity of the area.

In the report on "Fodder, Milk Supply and Land Utilization problems of Madras State" - 1949, a Government Publication the fodder problems of Andhra desa have been fully discussed and it is hoped that these will be considered in the light of the altered circumstances consequent on the creation of the Andhra State.

Similarly a note was prepared by the writer regarding the starting of Forest Industries in Madras State, to the Industrial Planning Committee of Madras in 1947. This has been published as Appendix XIII in the Final Report of the Industrial Planning Committee. This note also may be considered in this connection.

In conclusion the writer thinks that there is plenty of scope in Andhra desa for the development of forests and the industries based on them and that the new state will take them up in right earnest.

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WILD-LIFE CONSERVATION

A SPEECH BY LAKHPAT RAI
Chief Conservator of Forests, Madhya Pradesh

"Mr. Rotarian President, Fellow Rotarians, Ladies and Gentlemen,

"I feel very grateful to the Club and particularly to my friend Rotarian Jhaveri, the Chairman of the Programme Committee, for giving me an opportunity to speak to you to-night on the subject of Wild-Life Conservation, a subject of great topical interest. On a memorable occasion, the late Lord Reading a former Viceroy of India read his speech and the late Rt. Hon'ble Srinivasa Sastri remarked at the time, that Lord Reading was reading. I am also seeking your indulgence to read to you instead of giving you a 'talk'.

The interest in this subject as we understand it in the modern sense is of a recent origin say of about 70 to 80 years, and the movement for the preservation of wild-life started in some of the Western countries about that time. In our country, however, there have always been traditions favouring the preservation of wild-life. *Ahimsa paramo dharma* has been one of the basic principles of our ancient Hindu religion. *Ashrams* of the ancient *Rishis* were always considered as refuges of wild-life, where the animals roamed about, without any fear from the arrow of the mighty hunter. It will be recalled in this connection how the famous poet Kalidas describes in his drama *Shakuntala*, the scene when king Dushyanta approaches with bow and arrow in his hand, the *Ashram* of *Rishi Kanava*. King Dushyanta was about to let go his arrow at a deer in the neighbourhood of this *Ashram*, when a voice warned him that the deer belonged to the hermitage, and must not be killed. The famous book *Artha Shastra* of Kautalya also mentions the reservation of forests for wild animals, and also the existence of *Abhaya Aranya*, which means a forest where its denizens could roam about without any fear. You will also remember that Lord Gautam Buddha preached his gospel in the famous deer park of Sarnath near Banaras. It is even said that the name Sarnath is itself derived from *Sarangnath*, meaning 'King of deer'.

During his reign Emperor Ashoka, laid down detailed instructions for the preservation of wild-life. They still stand as an enduring monument in the 5th Pillar Edict at Delhi. The edict was promulgated in the 26th year of his reign. In this edict he said for instance 'The following animals were declared by me inviolable, viz., parrots, *mainas*, geese, queen ants, fish of various kinds, the rhinoceros, and doves, etc.' He also laid down in the same edict, that 'forests must not be burnt either uselessly or in order to destroy living beings'. Very much later, even the Moghal Emperors showed keen interest in the animal life of the country. Gradually the interest waned, and with the increase in population and spread of cultivation, as also the increase in fire arms, the destruction of wild animals started, resulting in their huge depletion. Deforestation and destruction of wild-life almost go together. This will be clear, if one studies the histories of ancient Greece and Rome and the Middle East. Even in our own country a greater part of the western and central region has become deforested and dry, with little or no wild-life about it. It is stated that at the time of the Indus civilization, wild elephants and rhinoceros existed in those parts. Much later in the Moghal times, Babar is reported to have hunted rhinoceros in the plains of the Punjab. In the past, the lion occurred over a great part of the western and central India, but now I believe, there are only two areas, where this King of animals is found, viz., parts of Saurashtra and Central India round about Gwalior and Jhansi.

The reasons for wild-life conservation are mainly scientific, aesthetic including recreational and economic. The scientists are always laying great stress on the need, of preventing rare

and interesting species from getting extinct. There are innumerable scientific investigations which can be undertaken only by the study of animal life. No doubt considerable amount of information has been collected by the study of dead specimens but it is the study of living animals alone under natural conditions which can lead to satisfactory results. It is not only humane considerations, which impell us to see that the wild animals are not destroyed, but it is also the aesthetic sense which appeals to most of us. I can conceive of hardly any person who will not derive pleasure, from the sight of wild animals in their natural surroundings. Some of you who may have a love for wild-life, may have their own experiences, but I have been privileged to see on various occasions, stags fighting for the mastery of the herd, a mother bear carrying her young on her back, a *chital* doe suckling her fawn, and parent bisons bending shoots of tender bamboo in order to help their young ones to feed on them. I have also seen a tiger in a rather unusual pose. I am sure that scenes of this type would delight any person. The wild-life of a country also provides an opportunity to the sportsmen for hunting and shooting, and to others for recreation. As regards economic reasons, the wild-life is a product of the land. It cannot be produced apart from the soil, waters, and vegetation which compose our environments. Being, therefore, an integral part of our environment, we are likely to destroy ourselves if we destroy the environment itself. Not only it is, therefore, necessary to maintain the balance of nature, but also to follow correct methods of wild-life management. Apart from these considerations they also produce furs, hides and horns which form a valuable asset to the country. It is reported that the annual sale of furs alone in London amounts to several millions of pounds. It also helps in bringing revenue from the sportsmen and encouraging tourist traffic.

In our fauna and flora, the bountiful nature has endowed us with a magnificient asset, and the wild-life of our country compares very favourably, with that of any other country of the world in its beauty and variety. There are more than 500 species of mammals found in India. They include the Elephant, the Wild Buffalo, the *gaur* or Indian Bison, the great Indian rhinoceros, the greatest of all the rhinos in the world, and the wild sheep and goat of the Himalayas. Among the deer species, we have swamp deer, or *barasingha*, the magnificent *sambhar* and the spotted deer, or the *chital*, being one of the finest of the deer species. There are various antelopes like the *nilgai*, 4 horned antelope, the famous black buck, white buck, and the beautiful *chinkara*. Among the larger carnivora we have the lion and the magnificent tiger, the various leopards and other animals of the cat species. The mighty boar almost occurs everywhere and the wild dog is not uncommon. We also have the flying squirrel. The avi-fauna of our country is also very rich and varied.

Coming nearer home, our own State can also boast of a very rich and varied fauna. We have no longer the elephant though I am inclined to believe that it must have existed before, nor do we have the lion though one was reported to have been shot not long ago in Betul. I have, however, grave doubts about that statement. Mr. A. A. Dunbar Brander, I.F.S., a late Conservator of Forests of this State, was of the opinion, that the central plateau was at one time the finest shooting country, and contained the finest fauna in the East, and that in the central plateau, the finest game in the tract was found in the C.P. This was some decades ago. Perhaps our State forests cannot now boast of this old glory, but something is still left of it. Glimpses of the same can be seen in the Kanha Game Reserve situated in the Banjar valley of the Mandla district. The older descriptions about forests and the wild-life in this tract are an eloquent testimony of this glory. Some of them I propose to mention to you for your information.

About Bison and *barasingha*, the Mandla Gazetteer says 'during the open season, the largest herds of bison are found in the Banjar and South Phen reserves, where there are several hundred head'.

As for *barasingha*, "their principal haunt is the Banjar Reserve, where several thousand head are to be found, and to a less extent the Motinala and North and South Phen Reserves, all of which are sal forests".

As regards Kanha-Kisli it says "The fame of Kanha as a shooting ground was widespread even in mediaeval times. In the cold weather *barasingha* lie up in most of the *maidans*, if they have not been disturbed, particularly in the great *maidan* east of Kanha and the neighbourhood of Shrawantalao. The Surwahi River is a regular high road of tigers". A local legend says that it was here that King Dashrath while out hunting, killed Shrawankumar mistaking him for an elephant. Shrawantal is known after Shrawankumar, and even the spot from where Dashrath is supposed to have shot his arrow, is pointed out.

I fear the conditions to-day are very much different.

The need for wild-life preservation has now been generally accepted throughout the country. The 1894 Forest Policy of the Indian Government omitted to take into account the wild-life of the country. The new forest policy of 1952 laid down by the Central Government, emphasises the need for affording protection to the animal kingdom, and particularly the rare species such as lion and the great one-horned rhinoceros, which are fast disappearing. An Indian Board for Wild-Life has also been constituted by the Government of India. In the forest policy of our State also, provision has been made in this regard by adopting 'a middle course'. The forest policy of our State provides, that (*i*) suitable forests of sufficient extent and well away from cultivation should be set apart as Natural Reserves and Game Sanctuaries, and that (*ii*) from forests abutting on cultivation, game destructive to life and property, should be exterminated.

Prior to the formulation of this policy the shooting in the reserved forests was controlled by the rules framed under the Indian Forest Act, whereas there was hardly any control on shooting in the large forest areas, which were outside the scope of the Forest Department. The general provisions of the Wild Birds and Animals Protection Act which applied to such areas were almost a dead letter. It was with a view to regulating and controlling the indiscriminate slaughter of the game in these areas that the C.P. Games Act of 1935 was enacted. The object of the Act was to control the unrestricted destruction of wild-life in the State, by licensing all shooting except for purposes of crop protection.

We may now see what is happening in other countries in this direction. As a part of proper land use, in the U.S.A., 3% of the total land area is devoted to Wild-Life Refuges, and 1% to National Parks, i.e., 4% in all for purposes of wild-life managment. The number of National Parks is in the neighbourhood of 40, and they occupy an area almost equal in size to that of Switzerland. They are managed by the National Parks Service of the Federal Government. It is reported that over 40 million tourists and vacationists visit them annually for relaxation. One such park, viz., Yosemite covers an area of 1,189 sq. miles. The following is a very brief description of his Park :

> "Yosemite is a scenic play ground. There are miles of autoroads leading to the many sights; miles of bridle paths for hiking, camping facilities and fine hotels complete with golf courses and swimming pools, 300 lakes and miles of mountain streams, stocked with trout to tempt the fisherman. Saddle horses and bicycles can be rented. It is not only a spot to visit in summer, but there is an all weather road leading into the park, and in the winter there are skiing, and other winter sports available. In the park, too are many kinds of wild animals. Visitors have to be warned constantly, that these animals are dangerous. Every effort has been made to keep it as really natural as possible. Anyone who cares to, can leave the road and in a few feet be in virgin wilderness. There is a charge of 2 dollars for entering the park".

In Africa there is the famous Krueger National Park, covering an area of about 8,000 sq. miles almost equal in size to the whole of Chhindwara or Raipur districts. This is perhaps the best known area for wild-life in the world. There are several other such parks. This park gets a subsidy of about £15,000 per annum from the Government, and the revenue from the tourists traffic amounted in 1951 to over £90,000. Some of you may have recently seen the film by name 'The Ivory Hunter'. It portrayed the wild-life scenes taken from this very park. You may also have noticed how much opposition there was in the beginning against the creation of this park as also the vested interests of the 'Ivory Hunter' in trying to sabotage the plan.

In Britain, due to lack of wild-life in the country, the National Parks there, are small and only of a scenic character.

In Japan there are 20 National Parks. The total area covered by them is about 6,000 sq. miles or a little over 4% of the entire area of Japan. They are administered in accordance with the National Parks Law enacted in 1931.

In India so far as is known to me, there are only 2 National Parks. There is one in the Uttar Pradesh called the Hailey National Park created in 1935, covering an area of 125 sq. miles and the recently created small National Park near Kanheri in Bombay. There are, however, various Game Reserves and Sanctuaries in the country. The Uttar Pradesh, has, for instance, its Rajaji Sanctuary, Mysore its Bandipur Game Reserve (here the real inner sanctuary is small in extent but has about 80 miles of roads so that the visitors can go all over), Madras its Mudumalai Wild Game Sanctuary, Travancore-Cochin its Periar Wild-Life Sanctuary where amenities for visitors are available in the shape of motor launches, Assam its Kaziranga Sanctuary containing the famous one-horned rhinoceros, elephant and other game.

In our own State we have the famous Kanha Game Reserve. The present areas of the Game Reserve is about 50 sq. miles, and it is proposed to enlarge it to about double the extent. The other Game Reserves are Bori and Taroba in the Hoshangabad and Chanda districts respectively.

I have already mentioned something about the old glory of the Kanha Game Reserve, but even now big herds of *barasingha* and *chital* can be seen round Shrawantalao and Kanha *maidans*. The two Forest Rest-Houses at Kanha and Kisli have been improved considerably, and some roads have also been constructed for the benefit of the visitors. There is an entrance fee of one rupee but even this is resented. It is situated in the heart of the evergreen sal forests of the Central Highlands of India in Mandla district, and can be reached by road or rail, the nearest rail-head Chiraidongri, being 27 miles from Kanha. The picturesque scenery of the wooded undulating hills covered with perpetual verdure, combined with the coolness of the forests makes it an ideal summer resort. The Union President, Dr. Rajendra Prasad paid a visit to this Game Reserve last March, and was delighted with the surroundings and the abundance of game he saw. It is a matter of pride to us, that the first meeting of the Executive Committee of the Indian Board for Wild-Life is being held at Kanha very shortly, when a lot of important persons are likely to be present.

I have already mentioned the important animals which can be seen in the Sanctuary. The number of birds one comes across in this Sanctuary is also quite large. Some of the common birds found in the Reserve are pea-fowls, red and other jungle fowls, sand-grouse, common quail, green pigeon, blue rock pigeon, snipe and several species of duck. An ornithologist of Bombay who visited this Sanctuary sometime ago, could identify many other birds, not easily known to a lay person. It may be mentioned that generally speaking, wild birds

are among the forester's best friends and no Game Reserve is complete without its wild birds. Food, water and nesting sites for them are essential.

In order to implement the new policy of the State in respect of wild-life, it is proposed to divide the forest areas into 3 categories, firstly Game Reserves or Wild-Life Sanctuaries in selected areas well away from the cultivation. For this purpose the creation of some National Parks is under the consideration of the State Government. Perhaps to start with, the Kanha and Taroba Game Reserves could be created into National Parks, and as experience is gained in the working of these Parks, more could be created later on. Other suitable areas can possibly be found in Bastar, Melghat, Chhindwara, and on the Amarkantak plateau. It will not be out of place here to point out the difference between a Game Reserve or Sanctuary and a National Park. The former is created under an executive order of the Government, and can be easily changed at will, whereas the latter is created under an Act of Legislature. Once a National Park, always a National Park. Our State has a total area of over 130,000 sq. miles and even if we allot a mere 2% for this purpose, we could easily have National Parks covering an area of about 2,500 sq. miles distributed in suitably selected tracts. Secondly the Government have also laid down that small and isolated blocks of 10 sq. miles in extent surrounded by cultivation will be thrown open to shooting, and wild-life therein can be exterminated as it is harmful to the surrounding cultivation. In addition to this concession the *nilgai* and the Wild Pig can be shot without any restriction. Cattle lifting tigers and panthers can also be shot without any restriction. Animals wounded by a cultivator in his field can also be followed up to a depth of half a mile within the reserved forests. The remaining forest areas will be divided into shooting blocks, and thrown open to controlled shooting for purposes of sport and recreation.

As there is no separate Department for Wild-Life Conservation yet in the State, though I am of the view that it would be desirable to have one (Bombay has already created one) the duties in this respect naturally devolve on the Forest Officer, and in his capacity as a Wild-Life Conservationist, he comes into apparent conflict with the public at large, and more particularly the agricultural population. In a Welfare State, the interests of the agriculturists must have a prior claim. Agriculture being the most important industry of the State, deserves a sympathetic consideration in this regard. The extent of damage to food crops through wild animals, however, is very much exaggerated, as there are other agencies also which cause this damage, e.g., monkeys, parrots and other birds, leave aside natural calamities, like floods, frost, locusts and other diseases. Among the wild game, wild pig is probably the principal crop destroyer, both in the open country adjacent to the forests and within the forests. When the balance of nature has not been disturbed, the larger carnivores take care of the surplus pig population harbouring in the reserved forests. In the open country, however, it is not the lone cultivator with his gun, who can make any impression on the wild pig, unless of course organized and persistent efforts are made to destroy them. People who clamour for such privileges of shooting wild game harmful to the crops, are not after wild pig, the main culprit, but after deer, as killing of a *sambhar* or *chital* is a paying proposition. Public opinion in this respect has to be educated. In this connection Mr. W. Russell Green of Madras State who is a cultivator himself, made a constructive suggestion in the columns of the *Madras Mail* not long ago. He has stated that the Government policy of issuing crop protection Arms licences was nothing short of legalizing the shooting of game animals, male, female and young from 'hides' by night, and was absolutely contrary to the game rules framed by the same Government. He said he had about 50 acres under cultivation adjoining a reserved forest and at one time was troubled by wild pigs. No pigs come near it now, and that without the help of a Crop Protection fire arm. He uses a piece of coir rope, with *deepavali* cracker fuses twisted into the rope at intervals, and lights the rope at 8 p.m. The rope smoulders and sets the fuses alight, and off go the crackers at intervals, which can be adjusted

by varying the distance between crackers. He thinks that about three or four of such crackers are more than sufficient for the night. This together with a couple or three pieces of cotton rope, set smouldering windward of the field, will keep the place absolutely free from raiding animals, and will go a long way to conserve the fauna. Besides no night watching will be necessary and the man's health not impaired and a better day's work would follow.

The talk on this subject will be incomplete, if I omit to mention a few words about the Zoological Gardens. The extent of a people's interest in wild-life can be gauged from the condition in which their Zoological Gardens are maintained. I have had occasions to visit many Zoos both foreign and Indian including the local Zoo. I am sure many of you must have seen lot of Zoos. It is hardly necessary for me to say, that the condition of the local Zoo does no credit to the rich and varied wild-life of the State. When I visited the Mysore Zoo about a couple of years ago, I was told that the late His Highness the Maharaja of Mysore used to visit it daily, and no wonder that it was maintained in an excellent condition. May I, therefore, appeal to you, and through you, to the citizens of Nagpur to have an up-to-date Zoo worthy of the State and of Nagpur. Much greater publicity is needed to educate public opinion on this subject, and to convince the people to take a balanced view. No scheme can succeed without the willing co-operation of the people. An eminent Judge has remarked that 'a law which is not acceptable to the many is made to be broken'. It is likely that we may have a Wild-Life Board for this State as well. I am of the opinion that it will be best to enlist public support for this matter by having some non-official members on the Board.

The subject is very vast and I fear I have not been able to do full justice to it, in this sketchy talk. If I have, however, succeeded even to a small extent in arousing some interest in this matter, I shall consider that I have not spoken in vain. In conclusion I thank you all for giving me a patient hearing.

MANAGEMENT OF SPRUCE (*PICEA MORINDA*) AND FIR (*ABIES PINDROW* AND *A. WEBBIANA*) FORESTS

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Spruce and Fir forests, which till about a decade ago were economically unimportant species, together occupy a much larger area than the other Himalayan conifers. The timber of these species is so much in demand now for various large scale uses which consume even the smallest pieces that the average price obtained considering all the sizes is almost the same as for *kail*, there being a very small difference between the prices per cubic foot of smaller and bigger sizes, unlike *kail* timber, where the difference is much larger, which brings down the average price. In addition the sale is much easier than of *kail* timber. The future big industry of news-print manufacture is also dependent on the supply of raw material from these species. A high sustained yield is the necessity for which immediate steps have to be taken without any more wastage of time. The over mature and mature crop which forms the bulk of these forests and which has been exploited heavily during the last decade cannot meet even the present demands for long and must be replaced as fast as possible to feed the industries and to produce a sustained revenue.

I. SYSTEM FOLLOWED AND RESULTS ACHIEVED

Both the spruce and the fir forests are invariably grouped under 'fir forests' for regeneration and management. Apart from the only attempt at concentrated regeneration in Kulu in search of a proper system of management, the rest of the forests have always been prescribed to be managed under selection system, which was the initial system for the management of conifers in the Western Himalayas. Want of enough regeneration of more valuable species, i.e., *deodar*, *kail* and *chir*, constantly drew attention and ultimately uniform system with shelter-wood fellings, and concentrated regeneration with a fixed period had to be introduced. The only attempt to change the system of management in fir forests of Kulu by Trevor in 1919–20 failed to work for want of demand for fir timber. During the last decade heavy fellings have been done in most of the fir forests in an unregulated manner. In many cases no yield was prescribed at all; in others the yield was fixed arbitrarily as a definite number of over mature trees to be felled annually, which was seldom adhered to. The felling cycles prescribed varied from 15 to 25 years, the latter almost amounting to seeding felling intensity in uniform system. The net result has been disastrous. Big permanent gaps have been created in the canopy. For want of serious attention to regenerate these areas, open canopy has resulted in dense weed growth, mostly though some spruce regeneration has been induced. These fellings are by no chance selection fellings and have caused a definite depletion of the capital due to regeneration not keeping pace with the removals. More often the lack of serious attention at regeneration of fir forests is explained by pleading lack of knowledge regarding regeneration and silviculture of the two species. By now sufficient information is available on the regeneration problems and the silviculture of spruce and fir.

Recently there had been a trend to express optimistic views regarding the progress of natural regeneration in fir forests basing on the presence of younger age classes under other species where they have appeared as a part of succession. Enumerations in the recent Kulu Working Plan by Aggarwal, K. L. have also been put forward as an argument for optimistic views. The appearance of younger age classes as a part of the succession of species in areas under different species is not by any chance the appearance of natural regeneration of these species in the sense a proper forest management demands.

The enumeration figures for smaller diameter classes would have been differently interpreted if the enumerations had differentiated between spruce and fir. My observations are that bulk of the smaller sizes is represented by dense to extremely dense evenaged groups of spruce poles standing around very old *kail* trees or their stumps towards the lower limit of spruce belt. Given proper spacing the number left will be less than half of the enumeration figures. The area covered is extremely small indeed as compared with the whole area under spruce and fir. Fir poles under spruce trees in spruce belt mostly singly and in open groups and sometimes in dense groups, form only a small portion of the smaller sizes. In fir belt younger age classes are represented very poorly and whatever are there, are found under broad-leaved trees, odd spruce and in small gaps under fir trees with side light and exposed mineral soil. Thus the younger age classes as met with in the forests now only indicate a movement of species in succession and not their regeneration under or around the mother trees in their belt as is the requirement of a proper silvicultural system. This should, therefore, provoke further analysis to evolve proper system of management to secure regeneration rather than lead to optimism.

In the forests opened up by exploitation spruce and fir have responded entirely differently. In areas where weed growth was not too heavy and the grazing incidence was moderate spruce seedlings and saplings are coming up in plenty with some *kail*. Odd fir seedlings under the shade of spruce are also observed in spruce belt. Within the fir belt in predominantly fir forests even with opened canopy fir seedlings do not appear except in some localized spots where mineral soil has been exposed. Generally dense weeds are taking the ground instead. This can be explained easily if analysed with the help of the available knowledge on the regeneration problem and the silvicultural requirements of the two species. In any case it is more than distinct that the behaviour of the two species constituting the fir forests is entirely different after creation of gaps in the canopy.

The latest working plan dealing with fir forests is for Kulu Division by Aggarwal, K. L. which has again prescribed uniform system with a fixed period, treating both spruce and fir together. Actually by now a stage has been reached when a more detailed analysis of the situation and a further change in the system of management is needed to ensure regeneration without loss of time and to avoid further depletion of the capital, which consists of mature to over mature crop almost entirely.

II. SPRUCE AND FIR WIDELY DIFFERENT SPECIES

The two species hitherto linked together for management are different altogether ecologically and silviculturally. The capacity to regenerate naturally, seed production, percentage germination, plant percentage, time of germination, root system of seedlings, resistance to drought, weeds, grazing and browsing, rate of growth, capacity to stand shade at germination and afterwards, is very dissimilar. Requirements of growth, i.e., light, moisture and drainage conditions of soil, depth of soil and climate are also different. The rate of growth itself, the influence of growth on edaphic factors and ecological status of the two species are very distinct. All these differences are exhibited in nature in the form of distribution of the two species. For successful management these two species cannot be lumped together as at present. These have to be separated for management purposes to ensure regeneration just the same way as *deodar*, *kail* and *chir* were separated in the past in an attempt to secure regeneration. The main characters which differentiate the two species and demand separate method of treatment are detailed below :—

(*a*) *Capacity to regenerate naturally* – (i) *Seed production*—Spruce is only second to *kail* in total seed production amongst the Himalayan conifers. Even in poor seed years quite large quantity of seed is produced. Unlike spruce, fir is the poorest seed producer amongst the

Himalayan conifers. A limited number of female cones are produced, chiefly on the upper part of the trees. Even in the bumper years of seed production, the total quantity of seed produced is very little comparatively. Average sized single cones of spruce and fir produce about 300 and 200 seeds respectively.

(ii) *Age and seed production*—Large trees of spruce continue to produce seed – almost till death. Spruce poles of twenty years age start bearing cones and viable seed. Trees of 3 to 8 feet girth are the best seed producers. Fir trees on the other hand produce very little or no seed at all after attaining large sizes. The tops of old trees tend to dry and such trees produce few or no cones even in good seed years. The seed production commences at thirty years age. Only moderate sized trees of 3 to 7 feet girth are good seed producers.

(iii) *Frequency of good seed years*—There is practically no difference in the frequency of good and moderate years of seed production.

(iv) *Seed weight and dispersal capacity*—Spruce seed is one-fourth in weight of fir seed, with almost the same size of wing due to which it is better equipped for dispersal away from the mother tree. Uniform spreading of seed ensures better natural regeneration.

(v) *Germination*—The percentage fertility of both the species is equal but the percentage germination of spruce is 42% as against 25% in case of fir, which further gets reduced in cooler situations. The fir seed germinates in April–May with the melting of snow which is followed by the severe summer drought period resulting in the death of majority of the seedlings. Spruce on the other hand commences to germinate with the advent of rains in June–July and continues for about a month ensuring good survival of plants even if there is a break in the monsoons. Under artificial conditions too where the drought factor is eliminated in case of fir the plant percentages are 76% and 66% for spruce and fir respectively. The spruce seedlings get a long growing period before the mild autumn drought months. Otherwise too the weeds in which the seedling grows during the rains protect it from the drought. Under natural conditions, therefore, there is a vast difference between the survival percentages of spruce and fir. A well developed root – more spreading than fir, also helps spruce seedlings to tide over the mild autumn drought.

(vi) *Resistance to weeds, grazing, browsing, drought and frost*—Spruce seedlings and saplings are commonly found growing above the weed level in areas open to grazing which indicates that these can stand reasonable amount of weed competition and grazing. Thriving spruce seedlings can be commonly located in thickets of weeds. It has been observed that the seedlings damaged by trampling and browsing easily develop side shoots and tend to recover. Of course repeated damage results in bushy saplings which are of no use as regeneration. Unlike this, fir seedlings are seldom found in areas open to grazing except in sheltered locations. It is probably partially due to weed competition but mainly because once damaged by trampling or browsing a fir seedling does not recover like spruce seedling. Cattle avoid eating spruce seedlings when other herbage is available though goats and sheep do not differentiate.

As regards drought, both spruce and fir seedlings develop a spreading root system but the roots of spruce seedlings always extend into much bigger area than fir seedlings and are thus better equipped to stand root competition as well as shortage of moisture. The moisture requirements of spruce seedlings are much less as is indicated by their survival on quite dry situations, as compared with fir seedlings which persist on very moist sites alone. Exposure to sun results in quick reduction in the moisture contents which the fir seedlings cannot stand. The leaf structure also indicates different transpiration degrees. In all respects spruce seedlings are hardier to drought.

Frost damages fir seedlings commonly but spruce is frost hardy. So much so that in Europe fir is classified as frost tender species.

(vii) *Rate of growth, moisture and light requirements of seedlings*—By the end of three years of growth spruce seedlings range from 3 to 6 inches in height and that of fir from 2 to 4 inches, though under exceptional conditions the seedlings may touch a height of 6 inches. Subsequently spruce grows faster than fir ; under favourable situations seedlings grow up to 1 foot 4 inches height by the end of 5th year and up to over 4 feet by the 10th year. Fir grows to barely 3 feet in 10 years time. The growth season of fir commences in April or early May and ends practically in June where as spruce continues to grow right up to autumn.

The seedlings of both the species develop a superficial fibrous root system in the 1st year when moist soil is needed for their survival, but as already pointed out the roots in case of spruce are more spreading due to which it can grow in a variety of moisture conditions – in conditions suitable to *deodar* seedlings on one hand and to fir seedlings on the other hand. Unlike this, fir seedlings can persist only in moist soil. Due to the higher moisture requirements frost tenderness and also probably different light requirements the fir seedlings need a definite overhead shade with side light to survive, where as spruce seedlings need plentiful overhead light with side shade to avoid desiccating effect of the sun. Once established fir seedlings cannot stand heavy shade though they would stand considerable overhead shade with side light ; overhead light improves the rate of growth, sapling stage onwards. Thus the requirements of moisture and light are entirely different for natural regeneration of the two species. Fir seedlings survive under the crowns of mother trees or other species, i.e., spruce and broadleaved species.

(viii) *Silvicultural and edaphic requirements : and rate of growth*—Spruce is a moderate light demander, ranking more or less equally with the *deodar* in this respect, but fir is a shade-bearer. Sapling stage onwards spruce needs a complete overhead light for optimum development, otherwise it gets suppressed. Fir saplings persist for many years under fairly heavy shade without suffering, though the rate of growth is retarded compared cases where a fair amount of over-head light is given. For natural pruning and production of clean boled timber fir needs much more side shade than spruce, i.e., the density of growth has to be much higher than in spruce ; in a mixed pole crop, the shade at which the spruce poles develop a clean bole, the fir side branches may persist to a very low level. Fir exhibits a very great tendency to form side branches low down on the bole, quite unlike spruce. Due to different light requirements, therefore, initial planting distance, cleanings, thinnings and ultimate harvesting will have to be different for successful management to produce maximum volume, which is bound to be the object of management with further development of industries needing fir and spruce timber as raw material. Spruce trees are apt to be killed on exposed aspects due to sudden isolation as has been observed in heavy fellings. This has also to be borne in mind to determine the initial intensity of fellings in the regeneration areas.

Both spruce and fir develop somewhat superficial and spreading root systems but fir definitely needs a deep rich moist soil for optimum development where as spruce can also stand shallower and comparatively dry soils, probably because of the lower transpiration loss of moisture, though spruce will also flourish as well as fir on deep moist rich soil. Spruce needs better drainage than fir which locally affects the distribution of spruce. As the acidity caused by deep humus does not penetrate deep into the soil, the extent of humus before exposure of soil which is essential for survival of the seedlings of both the species, seems to have no different effect on spruce and fir. In short apart from the capacity to stand lesser drainage and excess moisture in case of fir, there is no difference in the edaphic requirements of spruce and fir. Fir stands the persistence of melting snow for a long time in summer because of its different capacity to stand higher moisture and poor drainage, due to which it grows at higher altitudes and sheltered nullahs unlike spruce. Soil temperature differences being related to moisture and shade cannot be considered as part of the edaphic variations, but fact remains that fir

grows in soils with much lower soil temperature than met with in spruce forests. Given proper edaphic conditions spruce is found growing with fir right up to the altitudinal limit of coniferous growth. Actually on well drained soils it is spruce which persists in heavy snowfall zone and not fir – fir disappears in the inner valleys of the Sutlej in Bashahr where practically the whole precipitation is in the form of snow. Thus it can be clearly concluded that spruce is capable of growing on a number of areas at present under fir if the edaphic conditions are slightly altered. The localities suitable for fir alone are very limited in area.

It is unfortunate that no attempts have been made during last 30 years to collect the statistics on the growth and yield of spruce and fir. The only available data is from the earliest working plans which indicate;

(*a*) Diameter increment of spruce is much higher than of fir. On an average 105 and 139 years are needed by spruce and fir respectively to attain a 6 feet girth at breast height.

(*b*) Diameter increment continues both in spruce and fir even beyond 9 feet girth almost without decline but rot appears in the centre, earlier in spruce as compared with fir.

(*c*) Age height data, which is very limited indeed, indicates that from 20 years onwards fir grows faster than spruce. This data is not entirely reliable. However, the observations in the forests indicate that

(*i*) Fir grows taller than spruce.

(*ii*) Taper is more in fir.

(*iii*) Site quality variations are much more pronounced in height growth of fir.

(*d*) Fir is longer lived than spruce.

Diameter age relation is of great importance from management point of view. The existing observations are from natural forests. Actually the data collected in Jaunsar, Bashahr, Kulu, Chamba and Kashmir show lot of variations in diameter age relationship not only between the two species but within the same species as well. In Jaunsar almost equal rate of growth is indicated in both the species but in Kulu fir commences with a difference of 16 years age on the higher side at 12 inches d.b.h., which goes on increasing gradually till at 20, 22, 24, 28 and 32 inches d.b.h., it is 29, 31, 34, 39 and 51 years respectively. The data from all other places except Jaunsar supports Kulu trend, though no statistical reliance can be placed for want of not only inadequate observations but also because many unrecorded variables are not known ; the method of collection of the data may also have been different and faulty. In any case, as the matter stands now, it is evident that for the same exploitable diameter, whether small or large, a longer rotation, both financial as well as of maximum volume production, will be needed for fir. It is possible that ultimately given suitable treatment the difference in diameter growth between the two species may level out and the different rates of growth may not hold good as an argument to manage the two species separately but the other characteristics will always necessitate a separate treatment for the two species – sowing and planting distances, weeding, cleaning and thinning intensities, protection period for regeneration, exploitable diameters and rotation will have to be different to obtain the maximum increment.

(*b*) *Effect on edaphic factors*—Fir develops a long narrow crown as against comparatively much spreading crown of spruce. Due to this the fir trees grow much closer with a complete dense canopy while in spruce forests, even when in mixture with some fir, the canopy is not so dense. The different intensities of shade under these two species affect the soil temperature, moisture, vegetation and the rate of decomposition of the fallen needles.

Under spruce canopy some herbage is always found which not only permits grazing of a light intensity but also adds easily decomposable starter organic matter to the tough needles.

Light grazing disturbs the humus, hastening its decomposition and mixing it with soil and also keeps the herbage down. The solar light and heat penetrates, not being completely excluded by the spreading crown, the snow soon melts away and the excessive moisture evaporates or is lost by transpiration through the herbage and the trees. Suitable moisture and heat conditions are thus created for quicker decomposition of humus. Normally, therefore, spruce tends to maintain suitable edaphic conditions for its own regeneration or that of fir. When *kail* is in mixture, the conditions are better for spruce but if fir comes in to mixture, the edaphic factors are adversely affected according to the degree of fir mixture as is explained later. In remote areas where grazing is not common, openings in canopy permit dense weeds to come up, which obstruct the solar light and heat from reaching the soil and thus create unfavourable edaphic conditions similar to those under fir.

Under pure or high mixture of fir, sunlight seldom reaches the ground. Generally, the herbage is excluded completely which directly means exclusion of grazing. Otherwise too, the fir forests are situated far away and much above the habitations and below the alpine pastures. The animals just pass through these, only along definite paths. Snow also continues to lie till late in summer due to the poor penetration of light and heat. The soil temperature remains low and high moisture content is maintained by the slowly melting snow. The undisturbed layers of raw humus from spruce needles go on accumulating decomposing at a very slow rate particularly because of low temperature. The reduction of moisture by evaporation and transpiration is very much less than in spruce forests. The products of slow decomposition are strong acids which are inimical to plant growth generally. In badly drained soil the accumulation of the humic acid and carbon-di-oxide results in leaching of the bases. The unreleased nitrogen from the humus, because the nitrifying bacteria almost cease to exist, remains in an unavailable form. Otherwise too the coniferous needles are rich in complex carbohydrates which resist decomposition. These conditions are inimical for not only the regeneration of silver fir, but also of other conifers. On well drained soil, however, the acidic reaction of raw humus does not adversely affect the mineral soil to any great extent. At places where the complete canopy of fir is comparatively open due to the presence of big groups of broad leaved trees or where such groups form an under-storey, the easily decomposable leaves act as a starter to facilitate the decomposition of fir needles. It appears that the other factors, i.e., light, temperature, and soil moisture are also improved by the presence of the broad leaved trees. The mixed litter decomposes quickly liberating the nitrogen in available form without producing intermediate highly acidic products. The litter of the broad leaved species are also rich in bases. The plant food minerals are also liberated from the soil as a result of favourable litter decomposition. Thus conditions suitable for plant growth are created in the vicinity of the broad leaved trees. Depending on the degree of human interference, the advantage of these changed edaphic conditions is taken both by fir, and the broad leaved species to a greater or lesser degree.

(c) *Ecological Status*—Fir forest has been considered as the climax. One of the essentials of climax formation is that it must be able to regenerate itself to be stable. Regarding fir regeneration Suri, P. N. remarked "*Abies* regenerates under spruce and blue pine and in time first the pine and then the spruce are ousted by the fir, which alone can regenerate well in small gaps". The latter remarks are not borne out by the observations during the last decade or so. Fir has failed to regenerate in small gaps caused by natural death or by biotic factors, particularly because of the adverse edaphic factors explained above. Fir regeneration appears only either on mineral soil exposed by various factors or in areas with broad leaved trees where some degree of biotic interference also caused retrogression, without which the decomposing humus layers remain undisturbed which the tender rooted fir seedling cannot penetrate. In such places even, the regeneration is not fir exclusively but broad leaved species also come up giving a false appearance of successional invasion by fir. The powerful

broad leaved seedlings from big seeds penetrate though the deep humus and establish a contact with the soil, in which condition the fir seedlings stand no chance of survival at all. Presence of younger *Quercus semicarpifolia* in a narrow outer fringe all along the fir forest and of younger age classes all around groups of *Corylus colurna*, *Acer* sp., *Juglans regia*, *Celtis australis*, *Aesculus indica*, etc., in the very sparsely populated Pandrabis range of Upper Bashahr indicates a slow advancement of these into the fir forests. In certain other alpine areas with heavy grazing, fir has replaced *Quercus semicarpifolia* almost completely leaving only small groups, which are also bound to disappear in times to come. Fir is also commonly observed to be extending into the alpine moist deciduous forests of *Betula utilis* and *Rhododendron* sp. due to grazing by sheep and goat. It is these areas which give a false impression that fir is a climax species.

Regeneration of gaps in the remote fir forests is of special interest. Near the big broad leaved groups of the old trees in the sheltered nullahs, gaps are rapidly filled up by the regeneration of these species. In some cases where the lofty fir trees prevented the approach of broad leaved trees, fir has partially covered up the peripheries very gradually, as the humus accumulation disappeared, creating conditions of retrogression. The rest gets filled up with big bushes and herbs. In a couple of cases in Tranda range of upper Bashahr *Populus ciliata* trees have been observed right inside pure crops of fir, which seem to have appeared in such gaps. Rarely do very small gaps get filled with fir regeneration periphery inwards producing a very concave profile of the canopy.

These observations indicate that the mesophytic temperate deciduous forest which may have many more successional stages after fir is the climax vegetation of fir zone in the Himalayas. The pur fir or mixed coniferous fir forest is an unstable subclimax which appears to be stable because of the very slow rate of succession. The balance between the moist deciduous species and fir, in which condition both regenerate under ordinary conditions of human interference, seems to suggest that an alternation of subclimaxes of pure fir and the mixed deciduous broad leaved species is the only possibility of maintaining the fir forests.

Fir belt has been descending downwards into the spruce belt in most of the areas which could not be worked for want of market for these timbers till recently. The invasion by fir is very slow indeed, primarily because fir is a snow species and conditions are not very favourable for its invasion in the monsoon belt of spruce and also because it has a very poor natural regeneration capacity. The invasion of fir under spruce trees appears to be sporadic coinciding with good seed and snow years. In mature mixed spruce and fir forests it is evident that fir is much younger than spruce, which by now is rotten and hollow and has a tendency to die out. The pure fir forests are all mature to over-mature though the age variation is considerable indicating the gradual invasion in the past. Unlike this spruce forests show very little age variations in the mature crop.

Spruce unlike fir is a dynamic subclimax species which during the last fifty years of fire protection has filled up the gaps in the belt above 8,000 feet or so. It has come up either in mixture with kail or pure according to the extent of opening in the gaps. In bigger gaps kail has covered the centre and spruce has then occupied the peripheries producing a canopy profile slightly dipping towards the periphery. In smaller gaps spruce comes up without kail coming in. In addition, in many areas spruce has descended in a belt under deodar and open young kail crop. In some cases spruce forest has descended down to 7,000 feet in mixture with kail. Big groups of young spruce pole crops are often observed.

It is this appearance of groups of spruce and fir poles in gaps and under other species in a normal succession which has been taken as the normal regeneration of spruce and fir in these forests.

III. MANAGEMENT TYPES

The two species, at present lumped together as 'Fir forest for management purposes, being so different can be separated into the following two management types, basing on the broad principle that fir and spruce have to be separated for an optimum management.

(*a*) *Fir Forests, pure or more than 50% fir in mixture*—Starting from the altitudinal tree limit where the fir forests merge into the alpine deciduous forest belt of *Betula utilis* and *Rhodendrons* or of *Quercus semicarpifolia* where it has not disappeared by now, dominantly fir forests consisting of mature to over-mature trees, occupy a narrow belt, which is comparatively wider in the sheltered nullahs and on the northern aspect. In localities where the successional invasion of fir in spruce areas has continued unhampered for a long time, this type descends farther down forming a wide bolt, e.g., in some of the Kashmir fir forests. In other places, barring occasional groups, dominantly fir forests do not occupy very much area.

Big groups of the mesophytic deciduous miscellaneous type including *Acer* sp. *Corylus colurna, Celtis australis, Aesculus indica, Juglans regia, Simplocos crataegoides, Prunus padus, Populus ciliata,* etc., intercept the fir forests in the nullahs. The proportion of spruce increases on well drained and more exposed situations and towards the lower altitude where snow fall shows a decline. Occasional groups of high level kail and scattered over-mature spruce trees of bigger diameter than fir are found scattered or in small groups. Occasionally deodar trees are also met with in rocky shallow places.

Normally an under-storey is absent. Sometimes a few *Populus ciliata* in slightly open crop and small open groups of *Taxus baccata* in sheltered depressions on cool northern slopes under closed canopy of the mature to over-mature fir, form the understorey.

The ground cover varies considerably, primarily depending upon drainage, crop density and mixture of other species in the canopy. Under a complete canopy of fir or where the understorey exists, no ground cover is met with except occasional thickets of *Arundinaria falcata* and *spathiflora* mostly on flatter and poorly drained soils. In comparatively open fir crop with higher frequency of spruce *Strobilanthes atropurpureus* and *Wallichii, Impatiens gigantea* and *amplexicaulis* grow up tall and dense in the open spaces covering big areas. Poor drainage in depressions and flatter bits is a favourable factor for this type of under growth. In steep and well drained bits, towards the lower limit of predominantly fir forests, occasional *Indigofera gerardiana* may also appear over the *Strobilanthes* sp. and *Impatiens* spp. On warmer and better drained soils *Senecio rufinervis* forms a dense ground cover during the rains under the open crop, with occasional *Indigofera* sp., *Vibernum* sp. and *Spiraea* sp. in comparatively more open crop. Under the mixture with groups of broad leaved species, the ground cover is sparse and usually consists of the regeneration of those species and occasional fir seedlings mixed with light rainy season herbage.

The raw humus accumulation is the maximum under pure fir with or without *Taxus baccata* understorey. In the thickets of *Arundinaria* sp., *Strobilanthes* sp., *Impatiens* sp., and *Senecio* sp., the humus accumulation is as heavy as under pure fir forests and sometimes even deeper – occasionally over a foot deep black acid humus may be found in the heavy and tall under-growth. Under the broad leaved trees, however, the humus is well decomposed and the depth may be only about two inches or so.

The grazing incidence is very low except along the alpine pastures where fir is mixed with alpine trees and bushes. Lopping of the broad leaved species is common, particularly near the habitation.

(*b*) *Spruce forests pure or with less than 50% fir in mixture*—Below the predominantly fir forests a wide-belt of this type covers the greater part of the present so-called 'fir forests'.

Towards the upper limit of the belt, mature to over-mature more or less uniform aged groups of spruce are found mixed with groups of comparatively unevenaged old fir. Fir groups decrease in extent gradually lower down till occasional fir trees of younger age alone are met with in the sheltered portions. Groups of mature kail are quite common on raised well drained and exposed positions, where occasional deodar may also appear. Gradually deodar replaces the spruce till at 7,500 to 8,000 feet elevation the forests are predominantly of deodar. In the moist nullahs *Aesculus indica*, *Juglans regia*, *Acer* sp., *Celtis australis*, *Prunus padus*, *Ulmus wallichiana*, *Symplocos crataegoides*, etc., occupy big pure groups.

The understorey is generally absent but occasionally isolated groups of *Populus ciliata Corylus colurna* may be found. Fir saplings and poles in small groups or isolated are very often found under the spruce trees. Often quite big evenaged dense groups of spruce poles are met with in the open or under high crowned huge kail trees. Kail poles may also be found mixed singly or in small groups with spruce poles.

Bushy undergrowth of practically the same species as found under deodar, i.e., *Indigofera* sp., *Desmodium* sp., *Vibernum* sp., *Spiraea* sp., *Plectranthus* sp., *Berberis* sp., *Rubus* sp., etc., comes in and grows in varying mixtures and densities depending upon the aspect, altitude, drainage, overhead light and mixture of species in the canopy.

The ground cover mainly consists of the annual rainy season herbages but on protected situations and on poorly drained soils, particularly where the proportion of the groups of fir trees is comparatively high, *Strobilanthes* sp., *Impatiens* sp., *Senecio* sp., etc., which form big thickets under predominantly fir forests form small groups. Big formations of bracken fern and patches of *Siris* also cover the ground under the shade of spruce and kail trees. Bracken also grows in the open on easier ground. On southern and steeper aspects with more xerophytic conditions, *Salvia* sp., *Verbascum* sp. and some grasses also appear.

The raw humus accumulation is restricted to the small thickets of tall weeds, i.e., *Strobilanthes* sp., *Impatiens* sp., *Senecio* sp. and bracken, etc., but it is not so deep as in fir forests. Under bigger groups of fir the humus condition is not very dissimilar to that of the 1st type. Elsewhere the accumulation is at the maximum up to about 2 inches thickness. These forests are commonly used as the grazing grounds for the village cattle, sheep and goats being nearer to the habitation and also due to the plentiful herbage. Some areas are actually overgrazed which is responsible for very much drier type of flora, e.g., *Salvia* sp., *Verbascum* sp., *Plectranthus* sp., etc.

IV. REGENERATION PROBLEM

Various experiments and numerous observations in nature have lead to the discovery of the following factors which are inimical to the natural regeneration in fir and spruce forests.

(i) *Accumulation of raw humus*—The roots of fir and spruce seedlings fail to reach the mineral soil in humus layers deeper than two inches or so. As explained under forest types, this factor is of greater importance in predominantly fir forest where a heavy accumulation is found practically all over. In predominantly spruce forests it is generally shallow and the accumulation is very localized. Removal of thick humus layer is absolutely essential before the regeneration, whether artificial or natural, can succeed. This may be accomplished by physical removal in continuous or interrupted contour strips, or by burning or scalping, which is not feasible because it requires an intense fir to burn the moist humus which is uneconomical and may also harm the tender seed bearers.

In spruce forests natural regeneration of spruce in the gaps in canopy is commonly met with.

(ii) *Weed competition and early slow growth of seedlings*—Due to the competition with the dense tall weeds, the survival percentage of spruce and fir seedlings is very small. Removal of humus helps to reduce the weeds also. Controlled grazing can also be very useful in reducing the weed competition. Weedings are, however, necessary, to free the seedlings frequently till these are above weed level. Spruce seedlings are hardier to weeds and also are faster grown than fir, due to which much lighter weeding and cleaning intensity and frequency are needed and for a shorter period in their case though in the first two years there may be practically no difference in the areas of similar weed growth. As already indicated the extent and type of weed growth is entirely different in the fir and the spruce forests, conditions being less unfavourable for regeneration in the latter. Seedlings of both die under the more moisture loving weeds like *Strobilanthes* sp., *Impatiens* sp., etc.

(iii) *Poor seed production*—The existing mature to over-mature trees specially of fir produce very inadequate seed for natural reproduction. Whatever is produced has to be utilized in a concentrated manner artificially if the areas are to be quickly regenerated.

(iv) *Grazing*—Concentrated grazing in unprotected areas results in unsatisfactory regeneration even though heavy grazing helps to disturb the humus layer and expose the mineral soil at places. Browsing is particularly injurious and destroys the young seedlings. Overgrazing is common in some spruce forests. Even light grazing in spring and the rains is harmful when the seedlings germinate.

(v) *Debris accumulation*—The huge mature and over-mature trees of fir and spruce are mostly affected by a rot in the central core due to which the exploitable timber output is hardly 25% of the total volume in round. This results in huge accumulation of debris in the forests. The only method for its disposal at present is to burn it carefully avoiding damage to the seed bearers. Disposal by burning is extremely costly but it has to be done to clear the ground for quick regeneration.

(vi) *Exposure to hot sun*—Fir and spruce seedlings need side shade to maintain the suitable soil moisture conditions, the former being more sensitive than the latter. This can be provided by judicious, fellings – proper silvicultural system and careful weeding and cleaning. Heavy sudden opening in the canopy is undesirable for more than one reason.

(vii) *Bad drainage*—Due to too much moisture the seedlings may not germinate at all, particularly because of lower temperature. In such areas weeds are also heavy. Unsuitable areas have, therefore, to be stocked with broad leaved species.

The elimination of humus and exploitation debris are very costly operations. The regeneration must follow immediately to make the expenditure worthwhile else the weeds will take the ground. The poor seed production being an important limiting factor, it will be worthwhile incurring a little more expenditure on artificial regeneration. Transplanting of three years old seedlings of fir has succeeded very well at various places. This also ensures complete utilization of the limited seed supplies. In case of spruce, direct sowings have to be done as transplanting is not very successful ; the quantity of available seed is larger and the collection is also easier.

V. SUITABLE MANAGEMENT

Maximum volume production of clean-boled timber conserving the soil capital is the objective, which is possible only if the existing mature to over-mature fir and spruce crop is replaced in the shortest possible time at the minimum possible cost. If the two species are not separated for management average rotation and period of regeneration will have to be adopted. It will delay the speed of regeneration in the spruce forests which occupy a much bigger area than the fir forests. The average rotation can never be the rotation of maximum volume

production for both the species due to the different rates of growth. Production of clean-boled timber would also not be possible in mixed fir and spruce crops without affecting the increment of the latter as the intensity of thinnings will also have to be averaged, which will have to be much lighter than the requirements of spruce because a dense crop is essential for natural pruning of fir. All these effects of treating both the species together do not lead to the objective. Apart from the management problems, the technique of regeneration of the two types of forests also has to be different. It is, therefore, imparative that the two management types must be managed separately for quick conversion. Concentration of regeneration will be essential in both the cases to be quick enough, which, therefore, is the determining factor for the selection of the appropriate silvicututral systems, though the other factors like the silvicultural requirements, topography, etc., will also have to be considered.

In the fir type of forest a silvicultural systen which would permit gradual removal of mature trees with concentrated regeneration and will maintain certain amount of unevenagedness for protective purposes as well as for inducing natural pruning will be most suitable. Selection system does not exactly meet the light demand of fir. Actually it was due to this defect in the selection system that in Europe uniform system had been applied to fir, which proved to be the other extreme and resulted in poor regeneration and excessive weeds. Thus a compromise between the two is the silvicultural requirement of fir forests. Apart from this the present crop is evenaged for purposes of management, it being mature to over-mature. The system, therefore, has also to allow a flexibility in regeneration speed to convert the mature crop into an unevenaged crop. The irregular shelterwood system as followed in similar fir and spruce forests of Switzerland would meet all the requirements.

Considering that at present a d.b.h. of 24 inches is the most economical size of fir in the remote forests and is to be adopted as the exploitation diameter, the rotation should vary from 120 to 150 years depending on the site quality. The extent of irregularity in age in mature crop which would be desirable should range between 90 to 140 years for a rotation of 120 years and between 120 to 180 years for a rotation of 150 years. The regeneration period in this system is an indefinite but a long one and may vary from place to place according to the complicity of the problem of regeneration. It may vary within the same compartment even. Usually it may have to be extended up to about half the rotation period, in case of very bad areas. Any areas which are regenerated well can be excluded and new areas can be taken in. The regeneration areas, which may be very scattered, can be reallotted at short intervals, say of 10 years. The aim being quick replacement of the old crop, laxity in regard to the volume felled every year will also have to be allowed, check being applied over long periods, which may coincide profitably with the reallottment period, i.e., 10 years.

The method of regeneration will in any case have to be artificial, i.e., planting of fir after the handling of the inimical factors, which have to be kept in check subsequently also. But as experience has shown that pure fir crops offer problems of regeneration, a mixed crop has to be preferred, mixture being with quick growing broad leaved species and wherever possible with spruce, which also have to be introduced artificially to keep pace with fir. Sowing of spruce and planting of useful broad leaved species like *Acer* sp., *Corylus colurna*, *Populus ciliata*, etc. in the upper areas, *Juglans regia* in lower areas will be needed. Regarding the extent of mixture, broad leaved species can form an understorey in an open high crowned mixed crop of spruce and fir. The higher the mixture of spruce the better it is. Spruce will therefore, have to be introduced in all suitable spots in the fir forests.

This system will lead to diffusion of work and taking up of a large area for regeneration, needing close technical supervision and control. This is inevitable if the objective is to be achieved. In order to avoid neglect of areas and to keep up continuity of effort, shifting of

subordinate staff will have to be restricted to unavoidable cases only. Very detailed control maps and forms would be needed to keep a close check on the rate of progress.

In spruce type of forest the silvicultural system has to be such as to produce a more or less uniform crop to suit the light requirements of spruce. It also has to permit unevenagedness in places where protective function is of greater importance. A certain amount of flexibility in regeneration speed and fellings as pointed out in case of fir will be needed. The Punjab shelterwood compartment system which permits modification in theoretical principles of regular or shelterwood compartment system would meet the requirements of spruce forests.

Considering 24 inches d.b.h. as the exploitable diameter, a rotation of 100 to 120 years depending on the quality will be needed. In actual working a much shorter conversion period of say 80–90 years will be useful to hasten the replacement. Advance growth of fir or spruce whereever found can always be retained as future crop. The fixation of a nominal regeneration period during the conversion does not exclude the possibility of the method giving place to floating periodic block system later on if the regeneration proceeds fast enough, thereby permitting still quicker replacement of the mature crop. A period of 25 to 30 years is expected to be enough generally.

The method of regeneration will be natural but in unfavourable localities artificial regeneration by sowing may be obtained after the inimical factors have been controlled, which shall need watching throughout. Fir will be treated as a weed in the top canopy as its presence is primarily responsible for the problem patches in spruce forests. Wherever *kail* regeneration appears in groups or singly, it will be encouraged, though no special efforts to introduce it are needed. Deodar mixed in spruce forests always attains magnificent sizes. Towards the lower limits a little deodar can also be introduced artificially on raised well drained places. In moist and sheltered places, too cool and moist for spruce, *Juglans regia*, *Acer* sp., *Prunus padus*, *Celtis australis*, etc., will have to be planted, preferably with a little fir. Even if the broad leaved species outgrow the fir plants in early stages, later on fir will shoot through their crowns attaining a dominant position.

Generally, due to the difficulty of the problem of regenerating "fir" forest there is a tendency to take a static course in the working of these forests by adopting make shift arrangement for the removal of mature timber and leaving concentrated efforts at regeneration to the future. The problem is not so difficult if handled rationally and it is essential that immediate action should be taken to work these potential resources more scientifically.

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STUDY OF PLANT SUCCESSION IN KANHERI NATIONAL PARK, BOMBAY*

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SUMMARY

The Kanheri National Park, Bombay, falls under the moist deciduous climatic climax vegetation in which *Tectona grandis* and *Terminalia tomentosa* form fifty per cent of the trees. In one area about 300 feet high *Adina cordifolia* replaced almost completely the original vegetation after this moist deciduous forest was cut. On further cutting, *Adina cordifolia* is replaced by the *Bambusa arundinacea* more especially on the lower slopes of the hills near the rivers. After further cutting and disturbance a mixed shrub layer appears of *Holarrhena antidysenterica, Wrightia tinctoria* and *Calycopteris floribunda.*

On cutting the plants still further and pasturing, mixed stand of *Holarrhena antidysenterica, Themeda triandra Setaria glauca, Celosia argentea* and *Pseudanthistiria heteroclita*, plant succession. This is followed by *Eulalia fimbriata.* Finally in the area greatly trampled by man and intensively grazed by cattle *Eulalia fimbriata* in its turn has been found giving way to *Eragrostis unioloides* which forms the sixth stage of plant succession.

The ultimate result of indiscriminate pasturing, trampling and soil erosion is a ground totally rocky and stony with weeds like *Blumea eriantha, Eleusine indica, Cleome viscosa, Boerhaevia diffusa* and many *Cyperaceae.* However, *Blumea eriantha* having two-fold advantage of propagating itself vegetatively by stolons as well as by its light cypsella fruits, wins the ground and the seventh or the final stage of degradation is reached where in *Blumea eriantha* is dominating.

If, however, the vegetation is burnt at stages 2, 4 or 5 the ground in the next season is covered by *Pogostemon parviflorus.*

Thus it has been observed that as a result of intensive biotic activities moist deciduous forest has been reduced to mere grassland in Kanheri National Park, Bombay.

According to Clements (7) succession is the universal process of formation development. It has occurred again and again in the history of every climax formation and must recur whenever proper conditions arise. Warming (35, 36, 37) appears to have been the first to perceive the universality of change but paid relatively little attention to this important observation. It was left to Cowles (12, 13), Clements (5, 7, 8, 9), Tansley (34) and Cooper (10, 11) to investigate, develop and apply what was first incidentally mentioned by Warming. The detailed study of soil reactions and correlation between the changes in soil factors and development of plant succession has been studied by Salisbury (28, 29), Godwin and Bharucha (18), Godwin and Turner (19), Olsen (22), Eden (14), Geisler (16), Lee (21) and Watt (38, 39, 40). The other valuable contributions are those of Saxton (34), Bews (1), Salisbury (27, 30, 31), Phillips (23, 24, 25) and others which have greatly enlightened our ideas about the studies of plant succession.

The studies in vegetational development and plant succession has been greatly advanced and applied for the studies of the Mediterranean plant communities by the Zurich-Montipellier school of phyto-sociologists led by Braun-Blanquet. He has pointed out that a succession of

* This paper was read in the Botanical Section at the 39th Session of the Indian Science Congress at Calcutta 1952 and was accepted.

vegetation in the last analysis, is the exchange (appearance and disappearance) of species or a change in the quantitative relations of the species continuously present. Thus only when the existing equilibrium is obviously disturbed and the uniformity of the prevailing vegetation is visibly altered, then we are justified in speaking of a substitution of one dynamogenetic unit by another (3).

My studies on plant succession in Kanheri National Park are fundamentally on the lines to work out the influence of biotic factors on the course of plant succession and I have also investigated the degree of change in geographical elements that has been influenced by the biotic factors.

The area covered by the Kanheri National Park near Borivli comes under the West Thana Forest Division and falls, from the vegetation point of view, under the *moist deciduous* climatic climax vegetation. This climax consists of the two principal trees namely *Tectona grandis* and *Terminalia tomentosa*, which together form fifty per cent of the trees (33). But this climax vegetation is hardly to be seen to-day due to continuous disturbance and different systems of working out these forests. The result is that, nowhere to-day there is any trace of the original climax vegetation and the resultant effect varies with the intensity of the biotic factors of cutting, coppicing, burning and with the topographical features of the land. For example on an area East of Borivli varying in altitude from 150 feet to 350 feet, *Adina cordifolia* replaces almost completely the original climax vegetation after the cutting of this moist deciduous forest. *Adina cordifolia* gradually attains dominance largely because of its faster habit of growth, production of enormous quantities of seeds, with a greater capacity of germination even in comparatively drier soils and lastly the superior means of seed dispersal, being very light. The other species associated with this are *Butea frondosa, Trema orientalis, Bridelia retusa, Grewia tiliaefolia, Aegle marmelos, Sterculia urens, Holoptelea integrifolia, Glycosmis pentaphylla, Mitragyna parvifolia, Garuga pinnata* and *Terminalia tomentosa* are fairly representative. The ground flora in the shade of this association is very much similar to that found under true moist deciduous forest, viz., *Oplismenus burmannii, O. compositus, Neurancanthus trinervius, Commelina obliqua, Curculigo orchioides, Curcuma pseudo-montana, Triumfetta pilosa* and *Hapalanthus tentaculatus* while in open spaces *Triumfetta rhomboides, Pseudanthistiria heteroclita, Smithia conferta* and *Sida rhombifolia* are fairly common. This represents the second stage of plant succession.

On further cutting this stage of *Adina cordifolia*, it is finally replaced by the Bamboos (*Bambusa arundinacea*) more specially on the lower slopes of the hills near the rivers, where moisture is comparatively greater but, this stage is brought about due to the fact that the *Bambusa arundinacea* requires sufficient amount of light for the germination, as can be seen by the growth of the bamboo seedlings near the edge of *Adina* forest, where the canopy is lighter and the light intensity higher. Once the bamboo has germinated and established itself, it grows in clumps and casts heavy shade under which the flora is similar to the one growing under a heavy forest canopy, but due to continuous shade the vegetation is scanty and scattered as compared to that under deciduous forest, where light and shade phase are alternating. Light intensity measurements carried out with a photometer prove this assertion.

It was further observed that if, however, the pure or the mixed stand of *Adina cordifolia* or *Bambusa arundinacea* is further cut or disturbed its place is taken by the mixed shrub layer of *Holarrhena antidysenterica, Calycopteris floribunda* and *Wrightia tinctoria* which grows abundantly under the light canopy of *Adina cordifolia* and also under moist deciduous forest. This type of vegetation is found over the entire area of National Park in frequent patches of varying sizes. My field observations further confirm this view that this stage comes as a result of intensive biotic activity because :—

(1) there is a general absence of large characteristic trees which seem to have been cut down by man ;

(2) there are a number of small openings and general irregularity of structure;

(3) there are large number of seedlings and young ones of forest tree species found growing in the area like those of *Terminalia tomentosa*, *Pterocarpus marsupium*, *Butea frondosa*, *Dalbergia latifolia*, *Adina cordifolia*, *Schleichera trijuga*, *Bassia latifolia* and *Saccopetalum tomentosum*;

(4) there are certain forest indicator species which are found in this area, viz., *Curculigo orchioides*, *Tacca pinnatifida* and *Curcuma pseudo-montana* which suggest that the vegetation is one of the passing phase of plant succession towards climatic climax stage or represents a retrogressive stage due to cutting, as has also been indicated by Richards (26).

Further, the presence of large number of climbers, twiners and lianas, and the ground vegetation of good number of herbs and grasses, indicates that it presents a stage between true forest and grassland has been brought about by biotic activity. In this stage of succession, we find that about 38 species characteristic of dry deciduous forest have entered in the area due to the drier conditions caused by the removal of the plant cover.

On cutting down the plants still further and pasturing, *Holarrhena antidysenterica*, *Themeda triandra*, *Setaria glauca*, *Apluda varia* and *Pseudanthistiria heteroclita* and *Celosia argentea* form the fourth stage of plant succession. In this association other plants like *Crotalaria filipes*, *C. triquetra*, *Smithia hirsuta*, *S. sensitiva*, *Alysicarpus vaginalis*, *Themeda tremula*, *Brachiaria ramosa* with *Corchorus capsularis* and *Corchorus colitorius* are very frequently met with.

As the intensity of pasturing increases, *Pseudanthistiria heteroclita* is gradually replaced by *Eulalia fimbriata* Blatter and McCann, forming the fifth stage of plant succession. Finally in the area greatly trampled by man and intensively grazed by the cattle *Eulalia fimbriata* in its turn gives way to *Eragrostis unioloides* Nees, which forms the sixth stage of succession.

It may be mentioned here that the *Eragrostis unioloides* stage comes about not due to the operation of a single factor of pasturing but due to the operation of a combination of factors of over-grazing and consequently heavy manuring on hill slopes where the washed down soils from the hills form a humid habitat. Simultaneously with the regression of vegetation soil is also being washed off into *nallas*. Thus the ultimate results of indisciminate pasturing, trampling and soil erosion is a ground totally rocky and stony and fit only for useless weeds like *Blumea eriantha* D.C., *Eleusine indica*, *Cleome viscosa*, *Boerhaavia diffusa* L., *Cyperaceae*, *Sopubia delphinifolia* which invades the area and settle. However, *Blumea eriantha* having a two-fold advantage of propagating itself vegetatively by stolons as well as by its light cypsella fruits, wins the ground and the seventh or the final stage of degradation is reached wherein *Blumea eriantha* is dominating.

The above is an outline of the succession of vegetation that takes place at Kanheri National Park and brings about the existence of grasslands from the original moist deciduous forest due to cutting, burning and pasturing. It is further observed that as a result of intensive biotic activities there is a gradual increase of geographical elements characteristic of dry deciduous forest in each stage of plant succession. This indicates that there is deflected plant succession similar to the case stated by Godwin (17). Consequently we find a forest stage of less economic value to us than usual because of indiscriminate activities of man and animals.

If, however, the vegetation is burnt either at stage 2, 4 or 5, the ground is immediately covered in the next season by a large number of bushes of *Pogostemon parviflorus* Benth, as has been actually observed by me.

From the Table No. 1 showing diagrammatically, how the succession of vegetation has taken place, it can also be seen how *soil erosion* has taken place. The soil which has a depth

of approximately 5½ feet under forest, is only 5 inches deep under *Eragrostis unioloides* stage. Not only this but due to greater intensity of pasturing and trampling, the soil depth is reduced till we get almost stony and rocky ground under *Blumea eriantha*. This process of erosion is even accentuated by the tussocky habit of *Themeda triandra* and *Eragrostis uniolodes* which leave a lot of interspaces.

TABLE 1

Soil Depth		Laterite		
		Pre : existing Vegetation	Moist Deciduous Forest of *Tectona grandis* and *Terminalia tomentosa*	
			Cutting and Pasturing	Burning and Pasturing
Retrogressive Succession	60″	Cutting	*Adina cordifolia* facies	
	54″	Cutting and exposure to light	*Bambusa arundinacea* facies	Pogostemon parviflora
	30″	Heavy cutting	*Holarrhena–Wrightia* facies	
	24″	Cutting and pasturing	*Themeda pseudanthistiria–Celosia*	Dry deciduous forest.
	12″	Further pasturing	*Pseudanthistiria–Eulalia*	
	10″	Intensive pasturing	*Eulalia eragrostis*	
	7″	Maximum Regression	*Eragrostis–Blumea*	
	5″	—	*Blumea–Eragrostis*	
Progressive Succession		Closure to grazing		
	24″	:	*Themeda pseudanthistiria–Eulalia*	
			Holarrhena–Themeda	
	30″	Closure to grazing and prevention of cutting	*Holarrhena–Wrightia Calycopteris*	
	54″	Closure to grazing and prevention of cutting	*Bambusa arundinacea* facies	Dry deciduous forest.
	60″		*Adina cordifolia* facies	
	60″		Moist deciduous forest of *Tectona grandis* and *Terminalia tomentosa*	

Given due protection from cutting, burning and pasturing by law, the land can be regenerated fully in due course of time, and the vegetation would revert back to its original stage of moist deciduous forests, through suitable intermediate stages of varying types, which would enhance the value of Kanheri National Park for the study of virgin vegetation.

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HER LAST HUNT

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SUMMARY

The paper attempts to give an intimate insight into the habits and ways of life the South Indian Panther – *Panthera pardus fusca*. The characteristic way in which the panther goes about getting its food, the mischief which it is capable of making near human habitations, etc., have been portrayed, bringing out, in the incidents described, the animal's remarkable intelligence and reasoning power. The whole study has been narrated in the form of a story. Of special interest is the way in which a panther, driven to bay by wild dogs, often behaves.

This study was made in the forests of Mysore State between 1935 and 1940.

The female panther went ahead. Her mate, not quite as large as she, but perhaps even more savage, was at the same time more shy of approaching the habitations of man. Full of suspicions, but driven by the pangs of mid-summer scarcity, he followed at a little distance, while the female, crouching close to the ground, led the way across the open to the low, grass-muffled outhouses of a lonely wilderness farm.

She was a strange, forbidding and sinister figure, this fullgrown forest panther, and past her flower of youth, a kind of gigantic rough-haired cat with fine, large, proportionate pads of the size of a fullgrown alsatian dog, and hind legs and haunches handsomely developed as if in imitation of a mature hound. Her oval face, stiffly whiskered, and with a sort of soft down beneath her neck, and strong jaws, looked indescribably savage and wild, lit as it was by a pair of round, winking, palely-luminous eyes, and surmounted by sharp ears fantastically tufted inside. In ground colour she was of a shadowy light brown, faintly toned with a darker hue of the same colour on her back but fading off into creamy white on her belly, but richly spotted with rosettes of jet black all over her ample body, the rosettes fading away into solid spots in the region of her knees and ankles. Her grotesque but extraordinarily powerful hind-quarters were finished off with the straight stub of a once handsome tail, perhaps four or five inches in length. She might, in fact, have looked like a caricature but for the appearance of grace and power and deadly efficiency which she conveyed, the expression of menace in every movement.

Under the necessity of an empty stomach (1), the big panther had visited this forest abode once before, prowling as deep as she dared into the clearing, in the first shadow of a late summer afternoon. She had seen in the yard a couple of oxen – which were too big to interest her. What was more to her purpose, she had seen some huddling goats. Then, a draught of evening breeze blowing from the direction of the farm-house had borne to her nostrils the stink of man, and she had slunk off hurriedly to her jungle hide-out. But those goats ?

The smell of them, the remembered relish of a lamb which she had once devoured in the thickets (2), stung her appetite to madness. Like most of the wild creatures, she had learned, more from instinct than experience, that the strange looking, two legged beast was

(1) This was ascertained by opening out the stomach and entrails of the animal after it was shot.

(2) A week before this incident, a lamb had been lifted from the herd while the animals were out grazing in the neighbouring forest.

less to be dreaded by night than by day. So, well after nightfall, she had returned to the farm, bringing her ravenous mate with her.

At one side of the yard, startlingly bright in the light of the rising moon, stood the new - rich farmer's house (3) ; at the other side, two low, connected barns, with a shed running half-way to the house. The long, black shadows of the buildings stretched nearly across the open space between the farmstead and the forest. The open ground was hard packed and dried by the summer sun, covered with an inch of matty grass yellowed by the drought. The monsoon would soon come and turn the yellowed grass into green. Through the space of shadow the female panther crept like a denser shadow, till she reached the corner of the nearest barn. Here she crouched, making herself as small as possible, while she took a long sniff at one of the cracks in the warped, ill-seasoned, mango boarding. Then she turned her head, and looked at her mate, who was crouching some ten paces to the rear. As if this was a signal that all was as it should be, he ran nimbly forward and crouched again beside her.

From within, besides that warm, distracting, muttony smell, came confortable rustlings of dry hay and sounds of chewing, and safe contented breathings. It was obvious that the goats were in there. The eyes of the female, piercing and impatient, searched the blank wall before her. There was no entrance from that side. Furtively she led the way round the corner, her mate still keeping a prudent distance. At the edge of the moonlit yard she hesitated ; still there was no opening. Keeping carefully in the shadow, she prowled round to the other corner of the building, but with no better luck. Then, growing bolder, she ventured into the light and she crept down the front of the barn, flattening herself to the grass as she went ; her mate, yet distrustful, and now growing angry as he began to feel that he had been tricked, peered round the corner and watched her (4).

The female panther was now furious. She had expected to see those goats still huddled in the yard. Finding that they were inside the barn, she then expected to get in among them by the same way they themselves had entered. Where such fools as goats could, surely she could go. She knew nothing of doors that closed and opened, so she was puzzled. She drew back and stared up at the roof. Surely, the sheep must have got in by way of the roof. She could see no opening up there, however, so she went prowling round the other barn and the shed as well, finding everything shut up tightly against her. Then she came again to her mate, who was now awaiting her, tail and whiskers twitching with ill-humour (5) in the shadow behind the first barn.

But the panther was not yet prepared to acknowledge defeat. The roof of the shed was lower than that of the barns. With a masterly leap she gained it, but only to fall back ignominiously beneath a mass of grass which her claws had disengaged from the roof. In the next attempt, however, she got a grip with her front paws upon the roof itself, and so drew herself up, but not without a sharp rustling noise of scraping and clawing (6). The sudden sound disturbed the hens, roosting inside immediately below the roof, and they set up a shrill cackling of alarm.

The panther stopped, held herself rigid, and strained with all her ears. Chicken would do for her almost as well as goats - if only she could get at them ! She clawed savagely at the roof (7), but it was new and strong, and she speedily found that there was nothing to be

(3) The forest had been cleared and a farm established by an Anglo-Indian settler who had retired from railway service.

(4) The movements of the two panthers were ascertained by their pug-marks and the trial left behind by the animals as they passed through the herbaceous undergrowth of the forest clearing.

(5) The twitching of the tail and whiskers is a common sight seen when panthers are angry or they are about to pounce on thier prey. Their tail, however, twitches even if they are in playful mood.

(6) The two attempts, one successful and the other not, made by this panther to gain the roof of the barn were clearly visible from the disturbed thatch of the shed.

(7) This was judged from the badly disturbed condition of the roof at the place where the hens were roosting directly beneath the roof.

hoped for by that method of procedure. Frantic with baffled eagerness, she ran along the shed and sprang with a magnificent bound to the roof of the barn. At the thud (8) of this landing the cattle stirred and snorted uneasily (9), and the two horses whinnied with anxious interrogation.

At this instant the shutters of a window in the farm house flew out with a clatter. The panther turned her flat, cruel face sharply toward the sound and saw a jet of flame spurt from the dark window ; a crashing thunder shocked her sensitive ears, and something hummed viciously close above her head (10). Fortunately for her, the light of the moon is a deceptive light to shoot with. She left no chance, however, for the new-rich farmer to try second shot. With one wild leap she cleared the roof and alighted on the grass behind the barn. She saw her mate already fleeing, and she followed him, with long, panic-stricken leaps.

Well within the shelter of the forest, the female panther found her mate awaiting her. He stood, with his neck turned fully round beside his shoulder, eyeing her dangerously. What he wanted to convey to her by that glance cannot with any certainty be recorded, but it was certainly unpleasant, for she turned aside, in a casual way, and pretended to sniff with avidity at the stale trail of a civet. It was difficult, however, to develop any interest for any length of time in anything so hopelessly uncertain. After a couple of moments she wandered off stealthily, in search of some more recent trail. Her mate, though hot with disappointment and scorn, jogged along within a few bounds of her. In such a scarcity season (11) it seemed to be the interest of both that they hunt together, so far as their suspicious and morose natures and their frayed tempers made this possible.

The woods lay still as in death. The very air seemed muggy under the intense summer heat. The glare of the partly clouded and muffled moon was fleeting like a spot of light reflected from a ripply water surface. It seemed to devour even the strong, stealthy forms of the gliding panthers, to change them into a pair of drifting ghosts, which turned their heads from side to side as they went, and flashed from their eyes a pale, blasting glow (12).

But the female panther had a ghostly hunger – as had also her mate. Suddenly, her glowing eyes detected, under a spreading *jamun* (13) a spot where the ground had been disturbed. To a vision less keen it would have indicated nothing, but to her it was a clear, unerring indication. Turning sharply left from her trail, she pounced upon the roughness on the soil, and began digging furiously with her forepaws. In a few moments she was buried up to the knees, for the ground, here in the shelter of the trees, lay softer than in the sun-beaten fields. Sniffing her way by her well trained nose, she followed a deep trail which led in towards the trunk of the *jamun*. Her mate, meanwhile, approached and watched her enviously. A few seconds more, and her head emerged amidst a shower of mud. In her jaws she held a big field-mouse. The unhappy rodent had buried itself in the mud that it might escape its enemy whom it had seen approach like a phantom. For a second more its dying paws stretched and retracted spasmodically, then the panther crunched the life out of it and devoured her meal (14). The ill-humoured male came nearer, crouching with a conciliatory air, but the female was not a spouse of an obedient type, and a single field-mouse was not even half a morsel for a starving panther. With a vicious snarl she put out one

(8) (9) This noise actually woke us up from our sleep.

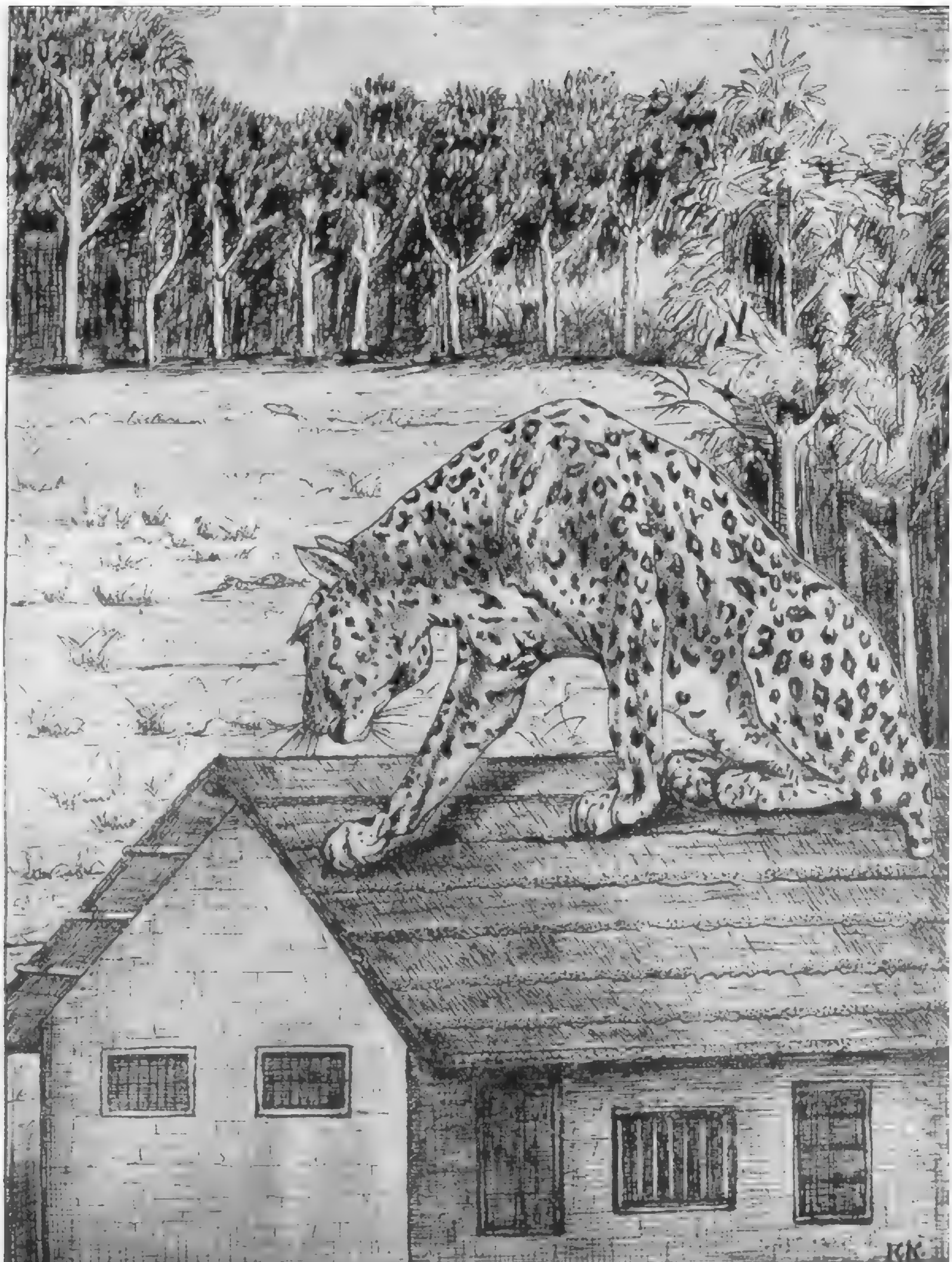
(10) This was a fatel shot but the author, unwilling to break the continuity of the narrative, has permitted himself the digression from actual facts.

(11) That year was a poor rainfall year.

(12) Normally this glow is visible only when a ray of light is directed towards the eye. The eyes of the carnivora, and in fact of practically all higher mammals excepting monkeys and man, glow in reflected light because of the layer of tapetum in the choroid coat of their eye.

(13) *Eugenia jambolana.*

(14) The author saw the field-mouse being actually devoured. This pather was also shot on the spot, and an examination of the disturbed soil proved the details of this event.



The Panther stopped, held herself rigid and strained with all her ears. Chicken would do for her almost as well as goats – if only she could get at them ? (see p. 97).

great paw in warning. Her mate stopped, licked his lips angrily, then turned like lightning and scrambled up a neighbouring *pipal* tree (15). His ears had caught the startled twitter which had answered the snarl of the female panther. There were wild-fowls nestling in that tree. His ivory claws, however, clutching at the bark, announced his coming, and for all his speed the birds escaped him, flying out blindly with terrified crowing to the neighbouring trees and perching themselves on the topmost slender branches where he could not go. Snarling with the anger of disappointment he descended the tree, and continued his prowl at a distance of some ten hops from his selfish mate who had by this time long finished the field-mouse (16).

For perhaps the space of a full half hour nothing more happened while the temper of the male panther grew each moment more dangerous. It was bad enough to be so hungry as he was, but to be led into a trap by his spouse and then to see her make a meal before his very eyes, this was hardly to be tolerated. All at once he gave a leap to one side, turning in the air as he sprang, and alighted on the ground, with his forepaws outstretched, and claws wide open, just at the edge of a half burnt bush. Out of the corner of his eye he had seen a wild-hen. With his miraculously speedy effort, as of a mighty gun recoiling in action, he had caught his feathered victim just as it was vanishing under the refuge. This was one of those unhappy birds which had attempted to fly out of the *pipal* tree but had fallen down, its body and feathers getting entangled in a neighbouring clump of thorny bamboo, and in its fall, had tried to disappear behind a dense thorny bush. For a second its strong wings flapped spasmodically, then the panther crunched the life out of it (17). The bird made one mouthful, to be sure, but it was quite as good as a wild-fowl would have been. He licked his chops, gave his spouse a side-long look, and walked on.

Slowly the moon rose up the starry sky shortening the shadows of tree and bush. The forest had been rendered more open here, having been recently gone over by the axemen and the fire which followed in their wake. Dense thickets, solitary trees, arrays of stumps and colonnades of tall secondary growth of teak, not yet heavy enough for the woodman's axe, followed one another in bewildering disarray. Suddenly, from a *lantana* bush just ahead, but hidden by some more teak thicket, came the sound of gnawing. Both the panthers like automotons crouched flat, the long handsome tail of the male twitching and the stumpy one of his spouse wagging. Then, separating, so that each could go on opposite sides of the *lantana* bush, they crept upon the heedless gnawer. As it came in sight of them, they stopped, for it was a full-grown porcupine, fat, offensively clad, and indifferent alike to weather and foe.

Full well did the two panthers know that this was no quarry for them. But they could not help yielding to their temptation. They crept nearer, their mouths watering. The porcupine went on gnawing his supper, but when the panthers came within a few yards of him, he stopped, put his nose between his forepaws erected his formidable quills, till he was looking nothing but a threatening array of pointed needles. The panthers crouched low and eyed him longingly. At last the male, his hunger getting the better of his discretion, stole closer and reached out a prying paw, as if to find out a weak spot in the scornful rodent's armour. His spouse snarled a warning, but at the same moment the rodent's tail – a mighty member covered with the tiniest quills – jerked sharply forward and thrust against the intruder's nose. With a splitting shriek the panther jumped back, half a dozen slender quills sticking in his nose as into a pin cushion. Rub and wallow as he might, he could not get

(15) *Pipal* is *Ficus religiosa*.

(16) This panther was actually shot while struggling amidst the branches of the tree. A most curious thing, one which person could hardly believe unless he is an eye witness to it, had happened. The neck of the panther had been caught as if in a vice in-between the forked branch of the *pipal* and the projecting branch of a *Terminalia* which grew next to it. The panther, this time a half grown animal, was actually hanging by its neck in mid-air, but was still quite alive. This incident occurred in the forest situated within 5 minutes walk of the spacious forest bungalow at Joldhal, a village 12 miles away from Bhadravati which is the seat of the Mysore Iron and Steel Works.

(17) Panthers are fond of poultry and in forest villages they are often a nuisance to poultry keepers.

them out, for their recurved edges held on inexorably. All he could do was to break them, and proceed, with the broken ends, rankling worse than honey-bee stings in his tender nose. From time to time he plunged his snout in the mud to allay the torment. And his temper was by no means eased (18).

All this, however, never troubled the female panther. Sure, the punishment to her mate had cooled her longing for porcupine flesh, but she had resumed her efforts of safe hunting. Concern for the consort's sufferings never entered her animal heart. He was of importance to her only if they should together find some big-game – a strayed ox or a *sambhur* – for instance, which they could bring down more surely and more easily by acting in unison. There was none of that close and firm intimacy which appears to exist, for instance, between a male and a female deer.

While traversing an array of big tree stumps the two came close together, though they continued to pay each other not the slightest attention. A light, dull footstep was caught by thier quick ears, and both crouched flat. The next moment a grey rabbit shot past them almost grazing their paws. With its large round eyes starting from its head in terror, the rabbit rushed past at such a pace that there was no time to strike it down, though the male, who was the furthest from it, made a futile sweep at it with his right front paw (19).

It was clear that some enemy must be following the rabbit, to cause it such mad panic. Whatever, it might be the two panthers had little fear of it. They waited for it, and in the next few moments it came. It came crashing noisily, in full gallop, head thrown forward, a slim, long – bodied, sinuous, fawn coloured beast with anxious eyes. As it galloped past her the female panther made a stroke at it and missed, but in the next split of a second the panther had pounced. He caught the left hind leg of the black-buck with both jaws in mid leap. Indomitable, it writhed up and kicked back its powerful, cleft and pointed hoof in his muzzle knocking out both his canines on one side. But unmindful of the punishment the panther's fangs closed about the slender tendon of its leg to snap it like a wire, crippling the leg, then the fangs closed about its slender neck and crunched its innocent life out of its handsome body. With the hot blood of his prey streaming from his nose and mouth, which eased, however, for a moment the galling ache of the porcupine barbs, he fell to his meat growling harshly over it. The female panther, perhaps imagining to herself that she had helped in the bringing down of this quarry, demanded a share, and seized one of the buck's fore-legs with her teeth. But with a defiant snarl the male struck at her, clawing viciously the side of her head nearest to him and scooping out one of her eyes. She was, therefore, in no anxiety to force matters with so determined an adversary, especially so because she had spied, at the same moment, at some distance another buck rushing on at full speed in her direction. She quickly drew off and sat down on her haunches to have a better look at the approaching animal. The black-buck was near her in the next moment, but hot on its heels she spied, to her dismay, a couple of wild dogs (20). With lightning speed she then stooped to a springing posture and leaping in the twinkling of an eye she caught her prey by its long slender neck which she wrenched out of shape in the next instant emitting meantime a sharp growl. In her anxiety to hunt she had almost forgotten her sub-conscious fear of the two red enemies

(18) This panther was also shot ; a large number of broken porcupine quills were extracted from its nose and from the padding of its paws. Obviously a porcupine had been killed and devoured by it.

(19) The rabbit was actually struck down and devoured.

(20) The wild dog event took place one early summer morning in a forest glade situated about a mile from the forest lodge at Rangiangiri. The author was out trying to shoot wild dogs whose destruction carries a reward. The evidence consisted of two dead black-bucks both having their leg tendons snapped, and one of them also having its neck broken and twisted out of shape, the hopelessly mangled body of a dead panther and six wild dogs lying dead around it. The author saw only that portion of the narrative up to the death of the second buck. The rest was seen by the late retired forester Lachma Nayak of Lakkavalli, a veteran *shikari*, who had joined the working plan party under the author as an Enumerator and had accompained him to the forest that morning. Lachma Nayak saw everything vividly from the top of a neighbouring tree and narrated it to the author on the spot with factual evidence. More evidence of the mischief of wild dogs was gathered by the writer near Muthodi (Kadur district) situated on the Hebbi-Muthodi forest road, which was in those days only a dangerous cart-track, and also at Kalkere in Mysore district.

she had spied. She now sat back to lick the blood oozing from the neck of her quarry and cleared her throat repeatedly by making a gurgling sound as if in satisfaction of her achievement, though her demeanour betrayed no small amount of anger. All at once her ears caught the fiendish yell of a score of wild dogs which made her start. Looking up she saw standing around her at a respectable distance a whole array of dogs, her mortal enemies. She still remembered her encounter with these animals once before when she was young, and how she had managed to make good her escape, thanks to her fleetness of foot (21). At first she saw the two of them, the vanguard of the pack, the ones which came close on the heels of the buck, advancing cautiously towards her, shoulder to shoulder, stopping every few paces as if repelled by her piercing gaze. She could tolerate this insolence no longer, nor could she brook her morsel being snatched out of her mouth at the moment she had settled down to its full enjoyment. Emitting a piercing growl of warning she sprang like a trained athlete in the direction of her intruders, her fore-paws outstretched, her mouth wide open displaying her ivory white canines, her sharp ears thrown back and whiskers elevated, her single eye spilling hatred and her whole figure couched in the sinister ferocity of a fighting feline. Her right paw descended on the spine of one of her enemies, broke it and bore down its body scooping out the entrails. Almost at the same instant her eager canines closed-in like a vice on the neck of the second dog severing it from the body as if cut by a pair of gigantic scissors.

She now looked round sharply for her mate, in the hope, perhaps, of getting his help ; but he was gone. The buck he had killed for himself lay there, ownerless and glossy eyed, and at the mercy of her adversaries who surrounded both her and it. The ring of dogs, now well established, began to close-in upon her, slowly at first, with obvious hesitation, but one among them, the leader, who surpassed the others in build and strength, emitting a yell louder than any of the rest, left the ring and surged forward. As if in shame at their hesitation five more dogs now joined him, two or three preceding him and the rest following close on his heels. They approached the panther step by step their eyes trained on her movements. The panther, now obviously in fear, looked round frantically for a way of retreat. She spied at first what she thought was a gap in the ring of her enemies but as she dashed for the opening she found the dogs there too ; only a *lantana* bush which had hidden them from her view had misled her. Disappointed, she turned round and charged madly at the ring around her now at one point now at another, but only to be hurled back each time by the sinister array of the canine dentition which faced her. When she drew back from her unsuccessful efforts she came face to face with the big dog, the leader of the suicide squad, and as her eye was rivetted at what appeared to be this her chief enemy she felt a sharp sting on her left hind leg. Like a powerful spring released from tension, she sprang sharply round and with a valiant stroke of her right paw delivered on its neck laid the intruder low in the next instant.

She now regained her former position to meet her main adversary, on whom her hatred rested most of all, but before she could act she found the back of her neck and one of her fore-paws caught in the sudden and secure grip of a number of her enemies. With her free paw she struck at the leader, now within striking distance, who went down senseless and with blood oozing from his mouth. She then dealt two mortal strokes at two more members of the suicide squad whom she could reach leaving them writhing with head and neck wounds which soon sapped their life. She now felt completely exhausted. She could not see her adversaries clearly. Her strokes fell wide and missed their target each time. Her free paw, which had so long remained her only weapon of offence and defence, was itself caught in the jaws of two more of her enemies, the two remaining dogs among those which had entered the ring with their leader.

She soon lay on the ground, prostrate and helpless. As her strength and power of action sank, she found the dogs growing bolder. One caught the stump of her tail and cracked it

(21) Panthers are able to escape from the onslaughts of wild dogs owing to thier fleetness of foot and I have oftentimes seen this happen. Lachma Nayak pointed out the scar of an old wound on the back of the dead panther which, he stated, had been caused by the bite of wild dogs.

between its teeth ; this gave her such acute pain that she gave off a mighty roar which made that dog release its hold. Another tore a piece of flesh from her haunches and a third snapped the tendon of her hind leg. She now felt stinging pains all over her body. The torture she was suffering was more than any she ever had known. Blood spatted from her body in every direction amidst tufts of dry grass and flecks of torn fur. But she, weakened by terror and horror at the incomprehensible fury of her numerous adversaries, had felt overmatched from the start.

In a few minutes her tense body, now nearly motionless, seemed to loosen. Her maniacal uproar which rent the air and echoed through the woods diminished into a panting growl. The dogs continued to worry her body for a few more moments. Then, as if coming suddenly to their senses, they stopped, drew off, eyed her mangled form and withdrew into the bushes. But before the last of her struggling breaths left her once handsome body now mutilated beyond recognition, she saw lying beside her at least six of her cruel adversaries their bodies stilled in death, their cruel eyes half open and staring blankly, as their limbs stiffened little by little in the mellow, cool, morning breeze.

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SLICED MAPS

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INTRODUCTION

The stimulus given by the International sub-commission on vegetation cartography of the UNESCO, in exploring new avenues for regional vegetation mapping, which may be utilized with advantage for the national economic planning, is a matter to which one should respond whole-heartedly (Bharucha, 1952). This is particularly necessary in tropical countries where systematic vegetation cartography has lagged behind, and where the exuberance and multitude of vegetational varieties make it necessary to devise systems for thorough vegetation mapping. The value of such maps is immense. They may indicate the occurrence of timber species of economic importance, plants of food value, medicinal plants, phyto-sociological characters of vegetation, suitability of land for cultivation, features necessary for the planning of forest management, data for land-use planning, etc.

Prior to devising a method of thorough vegetation cartography for tropical and allied forests, it is necessary to understand the differences between 'plant range' and 'plant distribution'. Turrill (1951) states that by 'range' is intended the geographical area within which, at a given time, a taxon or a plant community is to be found. Ranges can be mapped in various ways graphically to present relationships to environmental features, such as altitude, climate, or soil, or to demonstrate the resemblances and differences between the range of one taxon or community and that of another. 'Distribution' is the detailed occurrence of a taxon or community within its range, and signifies more intensive and more ecological study than merely indicating geographical extent. Further, it includes attempts to explain the facts of range and has, therefore, to take into account the past as well as the present.

In India, forest vegetation cartography or stock-mapping, as it is called, is practised since last seventy years, in connection with the preparation of forest working plans. The net out-come of this mapping is that we can have regional vegetation maps for most of the important tree species, e.g., *Tectona grandis*, *Shorea robusta*, *Cedrus libani*, *Ficus elastica*, *Pterocarpus santalinus* and *Santalum album* (Hole, 1909). Even the mass of information collected during this period, in various working plan reports, is so great that fairly accurate regional vegetation maps can be prepared from this source alone (Kadambi, 1950). Therefore, the problem in India is not of mapping the 'plant range' but of 'plant distribution'. Keeping this end in view, a system of *sliced maps* has been devised. This is particularly suited to forest vegetation cartography in tropics and sub-tropics.

HISTORY OF STOCK-MAPPING IN MADHYA PRADESH

This system of sliced maps has been evolved as a result of studying the past and present systems of stock-mapping and its future trends, in Madhya Pradesh. Its brief sketch, therefore, is necessary here.

In Madhya Pradesh, as in other States of India, forest vegetation cartography is a regular feature of the Forest Department. It is commonly known as stock-mapping. These stock-maps form the basis for the formulation of forest working plans. Prior to 1924, although the stock-maps were prepared for working plan purposes, they were of very sketchy nature

and were not based on any standard conventional signs. Some reasonable attempts, however, were made by Clutterbuck in Chanda and Townshend and Blunt in Raipur, etc. In 1923, the working plan of the Sal Ranges in South Raipur Division was taken up by Harlow. This plan not only marked the beginning of scientific forest management in Madhya Pradesh, but also laid down a systematic method of forest mapping (Harlow, 1924). The conventional signs then used were subsequently regarded as standard for the whole State (Maitland, 1926). The signs used were :

Forest	Definition	Standard colour symbol	Quality class	Definition (Height in feet)	Conventional sign on stock-map
(1)	(2)	(3)	(4)	(5)	(6)
Sal ..	Sal trees, 20% or more in the crop	Green	I	Over 90	Single vertical lines.
			II	70–90	Double horizontal lines.
			III	50–70	Treble diagonal lines.
			IV	Under 50	Light wash.
Teak ..	Teak trees, 20% or more in the crop	Blue	I to III	Same as above	Same as above.
Mixed ..	Without teak or sal	Red	I to II	Do.	Do.
			III and IV (combined)	Under 70	Pink wash.
Bamboos ..	..	Black	..	..	Vertical lines superimposed over the conventional sign of the forest type.
Forest village ..	..	Brown	..	..	Light wash.
Blanks ..	..	No colouring	..	..	Blank.

The simplicity of these conventional signs is due to the following facts :

(*a*) Only sal and teak were regarded as economically important forest tree species.

(*b*) Bamboo is another important forest product, mostly used by local inhabitants.

(*c*) The rest of the forest was regarded as unimportant and was lumped together under "mixed forest".

(*d*) Delimitation of 'forest villages' and 'blanks' was necessary from management point of view. They were treated as unworkable.

(*e*) The necessity to split IV quality sal did not arise, as these forests were unable to produce large-sized timber, usually in demand.

(*f*) IV quality teak did not exist in the area and, therefore, no conventional signs were adopted for it.

(*g*) III and IV quality mixed forests had practically no commercial value and, therefore, they were lumped together.

Gradually, as many other tree species came into prominence and many other features of the forests were regarded essential for the formulation of working plans, this simple set of conventional signs was gradually improved. This progress is tabulated below :

Year of introducing the symbol	Reference	Symbol adopted for	Definition (Height in feet)	Conventional colour adopted	Conventional sign	Reason for adoption
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1926	Working Plan of Mixed Ranges, South Raipur Division	Teak Forest IV quality	Under 50	Blue	Wash	Lower quality teak occurs in the area.
	(By Harlow & Dutt)	Mixed Forest IV*a* quality	40–50	Red	Hatching, vertical and horizontal lines	The low quality mixed forest had sufficient commercial value, as fuel and small sized constructional timber.
		Mixed Forest IV*b* quality	Under 40	Red	Pink wash	Do.
		Mixed Forest I to IV*a* quality (felled within last 10 years)	Usual	Gamboge	Back-ground wash in addition to usual conventional signs	Prior to the preparation of this plan large areas were felled and worked. Thus an inventory was made for the future planning.
		Mixed Forest IV*b* quality (felled within last 10 years)	Do.	Do.	Wash	Do.
		Poor unworkable forest	..	Chrome-orange	Do.	They indicated areas with poor quality forest and very open ; unfit for any rational working.
1938	Working Plan of North Raipur Division	Teak Forest IV*a* quality	40–50	Blue	Diagonal cross hatch	Low quality teak forest exists in the Division, and it being economically important was clearly mapped.
	(By Gurdial Singh)	Teak Forest IV*b* quality	Under 40	Do.	Wash	Do.
		Scattered teak	..	Do.	Dots	Do.
		Sal Forest IV*a* quality	40–50	Green	Diagonal cross hatch	Sal Do.
		Sal Forest IV*b* quality	Under 40	Do.	Wash	Do. Do.
		Scattered Sal	..	Do.	Crosses	Do. Do.
		Poor understocked forest	..	Yellow	Wash	To differentiate it clearly from forest villages.

(*contd.*)

Year of introducing the symbol	Reference	Symbol adopted for	Definition (Height in feet)	Conventional colour adopted	Conventional sign	Reason for adoption
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1938	Working Plan of North Raipur Division	Bamboo Forest I quality	Thick and long bamboos	Black	Vertical lines	Bamboo forest came into prominence all the more and, therefore, it was divided into two qualities.
	(By Gurdial Singh)	Bamboo Forest II quality	Thin and short bamboo	Do.	Diagonal lines	Do.
1942	Working Plan of Akola Forest	Teak Forest IV*b* quality	30–40	Blue	Vertical and harizontal hatching	It carries even the poorest forest which is also important economically in the locality. Thus it has been further divided.
	(By Cornelius)	Teak Forest V quality	Under 30	Do.	Wash	Do.
		Mixed Forest IV*b* quality	30–40	Red	Vertical and horizontal hatching	Mixed Do.
		Mixed Forest V quality	Below 30	Do.	Wash	Do. Do.
		Anjan (*Hardwickia binata*) Forest. IV*b* quality	30–40	Green	Vertical and horizontal hatching	These forests were required to be shown on the maps, being economically important in the locality, and thus the appropriate signs were devised. Green colour was adopted because sal and *anjan* occur in distinctly different localities in Madhya Pradesh.
		Anjan Forest V quality	Below 30	Do.	Wash	
		Scattered Anjan	..	Do.	Single vertical lines	
		Bamboo plantation	..	Black	Vertical and horizontal hatching	
		Scattered Sandal (*Santalum album*)	..	Red	Plus marks	
		Scattered teak	..	Blue	Do.	
		Deep Black soil	..	Violet	Back-ground wash	These are the main soil types occurring under *Babul bans* (*Acacia arabica* forests), and as the agri-silvicultural system is practised there, these soil types were also represented on the maps.
		Light Black soil	..	Brown	Do.	
		Calcareous soil	..	Blue	Do.	
		Poor stony soil	..	Red	Do.	

(*concld.*)

Soon after the World War II, when large scale stock-mapping was undertaken to revise the existing working plans and to determine the extent of war fellings, all these stock-mapping symbols were compiled by Rai (1946) and he summarized them as under :—

Forest	Conventional Colour	REMARKS
Teak	Blue	
Sal (in the eastern parts of the State)	Green	Scattered teak, sal or other species may be shown by writing letters, T, S, etc., as the case may be.
Anjan (*Hardwickia binata*) in the western parts of the State	Green	
Mixed Forest	Red	
Understocked areas ..	Yellow	
Blanks	No colour wash	
Forest villages	Brown	

The quality classes are represented as follows :

Quality	Definition (Height in feet)	Conventional Symbols	REMARKS
I	Over 90 ..	Single vertical lines	
II	70–90 ..	Double horizontal lines	
III	50–70 ..	Treble diagonal lines	
IV*a*	40–50 ..	Diagonal cross hatch	
IV*b*	30–40 ..	Vertical and horizontal hatch, if V quality also exists, otherwise wash	
V	Under 30 ..	Wash	It is being recognized only in Berar districts of the State.

He further emphasized that it may be necessary in places to show *khair* (*Acacia catechu*) areas, areas suitable for the lac propagation, and also areas carrying *semal* (*Salmalia malabarica*) trees. *Bija* (*Pterocarpus marsupium*) is a valuable species in North Chanda Division, and it was considered desirable to show its occurrence on the stock-maps. Similarly, *tinsa* (*Ougeinia dalbergioides*) is a valuable species in Hoshangabad. Suitable symbols were designed to show all of them on the maps. These instructions, however, were not considered sufficient because a number of other species also came into prominence and all of these were to be represented on maps. An uniformity in the adoption of symbols was, therefore, desirable. Therefore, several circular orders were issued to over-come difficulties encountered by

working plan officers. The additional and revised symbols, which were thus introduced, are :

Circular Order No.	Features to be represented	Conventional signs prescribed
(1)	(2)	(3)
WP/131, dated 17-4-1946 ..	Frost liable areas	F.L.
	Eroded areas	EROSION
WP/957, dated 23-4-1946 ..	Permanent water hole	Black border with blue wash.
	Salai (*Boswellia serrata*) trees, scattered ..	Orange, S
	Teak trees, scattered	Blue, X
	Sal trees, scattered	Green, S
	Anjan trees, scattered	Green, X
	Scattered trees of *bija*, *semal* and *papra* (*Gardenia latifolia*)	By dots of various colours.
WP/1898, dated 4-7-1947 ..	Protection Forest	Red wash.
	Tree Forest	Green wash.
	Minor Forest	Alternate green and orange horizontal lines.
	Pasture Forest	Orange wash.
	Forest village	Brown wash.
	Grass reserve	Orange horizontal lines.
WP/1877, dated 2-7-1949 ..	Monsoon closure areas	Blue thick dots.
WP/177, dated 14-1-1950 ..	Bamboo, I quality	Black vertical lines.
	Bamboo, II quality	Black diagonal lines.
WP/430, dated 18-2-1950 ..	Age classes – Mainly old	Light red background wash.
	Mainly middle-aged	Light blue background wash.
	Mainly young	Light green background wash.
	Teak plantations, below 10 years of age ..	Blue strokes with brush on green wash.
	Miscellaneous plantation, below 10 years of age	Red strokes with brush on green wash, and name of species.
	Teak plantation, 10 years and over in age ..	The word "PLANTATION", and if possible, year of formation below it, on green wash.

(contd.)

Circular Order No.	Features to be represented	Conventional signs prescribed
(1)	(2)	(3)
WP/430, dated 18-2-1950 .. (*concld.*)	Miscellaneous plantation, 10 years and over in age	The word "PLANTATION", name of species and if possible year of formation.
	Natural reproduction, established and fairly common of—	
	Teak	Blue + sign
	Sal	Green + sign
	Miscellaneous ..	Red + sign
	Scattered individual species of—	
	Salai (*Boswellia serrata*)	Orange, S.
	Khair (*Acacia catechu*)	Burnt sienna, K.
	Semal (*Salmalia malabarica*)	Black, Sl.
	Kullu (*Sterculia urens*)	Black, K.
	Bija (*Pterocarpus marsupium*)	Black, B.
	Mowha (*Madhuca indica*)	Green, M.
	Harra (*Terminalia chebula*)	Green, H.
	Ghont (*Zizyphus xylocarpus*)	Violet, G. } Lac host trees.
	Kusum (*Schleichera oleosa*)	Violet, Km. } Lac host trees.
	Palas (*Butea monosperma*)	Violet, Ps. } Lac host trees.
	Ber (*Zizyphus jujuba*)	Violet, Br. } Lac host trees.
	Areas having lac hosts mainly	Violet wash.

Besides the above symbols, it was also felt during the course of stock-mapping in South Raipur Division to adopt a few more signs (Khan, 1951 and 1952). They are as follows :

Features to be represented	Conventional colour	Conventional sign	REMARKS
(1)	(2)	(3)	(4)
Regenerated sal areas ..	Green	Light uniform wash	A vast area of sal forest was completely regenerated and it was necessary to represent it for management purposes.
Dessity of Crop :—			
0·6 to 1·0 ..	No colour	No wash	Fit for intensive working.
0·3 to 0·5 ..	Yellow	Light wash	Fit for light working.
0·1 to 0·2 ..	Chrome-orange	Do.	Unworkable.
Worked forest :—			
Old or middle-aged ..	Yellow-green	Light uniform wash	} Necessary to distinguish for management purposes.
Young	Green	Do.	} Necessary to distinguish for management purposes.

Similarly in other working plans of the State, various other symbols have been adopted to meet the local needs. Thus the variety of these symbols is on steady increase, as more and more forest species are becoming commercially important and more basic data are required to implement thorough scientific working. The scale of maps adopted is usually 4″ = 1 mile, but in certain divisions 2″ = 1 mile maps are also in use. They represent topographical features also, in addition to these colour washes and symbols. The net result is that they appear very much crowded and one of the chief aims of mapping, i.e., clarity, is badly defeated. To keep up the desired standard of clarity it is necessary to limit the number and kinds of symbols, so that the names of places, courses of rivers, contours, etc., do not get smudged. Unfortunately, the number and kinds of these symbols cannot be reduced. Therefore, it is necessary to evolve a system to over-come this difficulty. The method of sliced maps is designed to meet these ends.

MAGNITUDE OF THE PROBLEM

Besides the list of symbols mentioned above, it is also necessary to make room for further details which are likely to be represented on maps in future. Thus the magnitude of the problem may be assessed under the following categories :

(*i*) Representation of locality factors for the ecological understanding of the vegetational growth.

(*ii*) Representation of phytosociological types to base the management on ecological basis.

(*iii*) Indication of plants of economic value, which are found as sporadic associates, in the general vegetation type.

(*iv*) Representation of forested lands, pastures, agricultural areas, habitations, bare grounds, etc.

(*v*) From forest management point of view, to represent quality, maturity and density of forest together with the occurrence of the natural regeneration of economically important species.

Locality factors—In India, the stock-maps are prepared for each forest division separately ; and under Indian climatic conditions temperature does not seem to influence the vegetational growth appreciably from place to place, within the limited area of any one division ; primarily because, the range of temperature is not sufficiently wide to cause any marked difference. Its effects are noticeable to some extent only in the Himalayan region and north-western arid zone, when compared with the rest of India. Precipitation and humidity jointly play an important role in the distribution of vegetation and the representation of this factor on the maps is a prime necessity. The main items to be represented are : (*a*) total annual rainfall, (*b*) rainfall during the summer season, (*c*) total number of rainy days during the year and (*d*) total number of rainy days during the summer season. Unfortunately, the number of rain-gauge stations is not adequate to represent precisely the local variations. Before this factor is reasonably represented on maps, a network of rain-gauge stations shall have to be set up. The next important locality factor is soil. So far no thorough soil surveys have been made in this country. It shall have to be undertaken now, as the vegetation types seem to correspond strictly to the soil types. Soil-moisture factor is another important item which needs consideration. Similarly, soil pH, and soil nutrients may be looked into. Other locality factors like light, wind, snow, etc., may be considered only in special cases. Topographical features are already represented on the forest maps of this country.

Phytosociological types—The only authentic work done in this respect is that of Champion (1936). He recognized the following types :

Groups	Associations	Constituent forest types
20	54	106
The vegetational types occurring in Madhya Pradesh are :		
7	8	12

This is, however, only a preliminary work and a multitude of vegetation types is yet to be studied and recognized, before this work is finalized.

Economic Plants—India carries a more varied flora than that any other country of equal area in the eastern hemisphere. Hooker (1906) estimated that the number of recorded species of flowering plants approaches 17,000, under 174 natural orders ; and there are probably 600 species of ferns and their allies. All of them, however, are not valued commercially. But the usefulness of a fair number of them has been recorded by Watt (1885–1893). As researches are progressing, more and more plants are coming into importance, which were, hitherto, not regarded of any importance.

For Madhya Pradesh, no single flora exists which describes all the plants occurring in the State. The following is the brief summary of the existing floras :

FLORA	Hole (1906)	Witt (1908)	Witt (1911)	Graham (1913)	Haines (1916)	Witt (1916)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Region of M.P. covered	Northern	Western	Western	Central	Eastern and South-eastern	Northern and Western
Total No. of plants recorded	356	333	80	184	564	585
Medicinal plants ..	5	44	..	..	51	174
Plants yielding edible fruits, roots, etc.	33	59	..	..	58	127
Timber trees	42	44	..	..	54	88
Bamboos	2	..	2	..	2	2
Fibre-yielding plants ..	..	11	..	..	14	26
Gum-yielding plants ..	2	6	..	..	17	18
Ornamental and hedge plants	75	36	..	..	26	34
Food-grain yielding grasses..	..	..	5	7	5	8
Good fodder grasses ..	..	..	30	48	14	18
Absolutely useless grasses ..	..	..	7	7	7	..
Grasses used in thatching and for brooms	..	..	5	3	4	3
Others	197	133	31	119	312	87

This clearly indicates that a mass of information shall have to be represented on maps, in future. Therefore, keeping in view the needs of the future, the system of sliced maps devised now, is most suitable.

Representation of data for the planning of land management—For the purpose of the nation-wide need for the planning of land management, it is desirable to show on the maps, the forested areas, cultivated lands, pastures, forested lands combined with pastures, barren grounds which warrant afforestation, and the basic data for the implementation of soil conservation works. Soils suitable for cultivation, but not brought under plough yet, also need to be indicated.

Representation of data for the economic planning of forested lands—This is important for the formulation of forest working plans. The data which needs to be represented on maps, in this connection, is as follows :

(*i*) Type of forest, such as teak forest, sal forest, bamboo forest, *babul bans* (*Acacia arabica*) forest, *anjan* (*Hardwickia binata*) forests, etc.

(*ii*) Quality classes of these forests.

(*iii*) Maturity (age) of the forests.

(*iv*) Canopy and stem density.

(*v*) Scattered forest species of economic importance.

(*vi*) Natural regeneration of economically important species, together with the degree of their establishment and gregariousness.

(*vii*) Reasonable details of forest structure, i.e., the component species occurring in various strata of forest profile. Representation of grasses which are useful for grazing or otherwise, is a growing need of the day. The occurrence of various grasses also serves as a useful indicator, whether a particular forest species will regenerate successfully in the locality or not. The representation of various kinds of grasses is also useful for the planning of fire-protection measures in the forests. Thus these maps should also serve as *'fuel type'* maps (Wright and Beall, 1944).

(*viii*) Soil types which regulate the occurrence of forest types must be shown on maps. A better understanding of soil-vegetation complex is sure to lead to better scientific forest management. A representation of geological features is also desirable to some extent.

(*ix*) Management details such as, compartment boundaries and numbers, boundaries of forest ranges, felling series, coupes, etc.

SUGGESTED METHOD OF SLICED MAPS

It has been observed that if all the stock-mapping symbols are complied with faithfully (Deep Singh, 1953–54), as are prescribed at present in the practice of Forest Department in Madhya Pradesh, the maps get so much over-crowded that the clarity is completely lost. It is, therefore, necessary to substitute a set of maps for the present single map and the details be distributed on them, in such a way that when the clarity is ensured, the intelligibility is not overlooked. If we imagine the entire soil-vegetation complex as a solid mass, and again if we imagine to slice it down in transverse sections, and when we prepare maps separately for each section, the set of maps so prepared for one soil-vegetation unit, these maps are termed the "*sliced maps*". Usually it is convenient to prepare five sheets of sliced maps for one vegetation unit. The details are as follows (also see Fig. I).

(*i*) *Top Canopy*—The details to be represented in this tier are, forest type, main constituent tree species, trees of economic value, classification of canopy, stem density, etc. One sheet of sliced maps is devoted to it..

(*ii*) *Middle-storey*—The details to be represented here, include the structure of middle-storey. Therefore, here also only one sheet of sliced maps is assigned.

(*iii*) *Ground flora together with geological and soil details*—Considering the fact that the nature of vegetation depends on soil types, in which the plants take their roots, and the mass of information which is required to represent this section, three sheets of sliced maps are allotted to it.

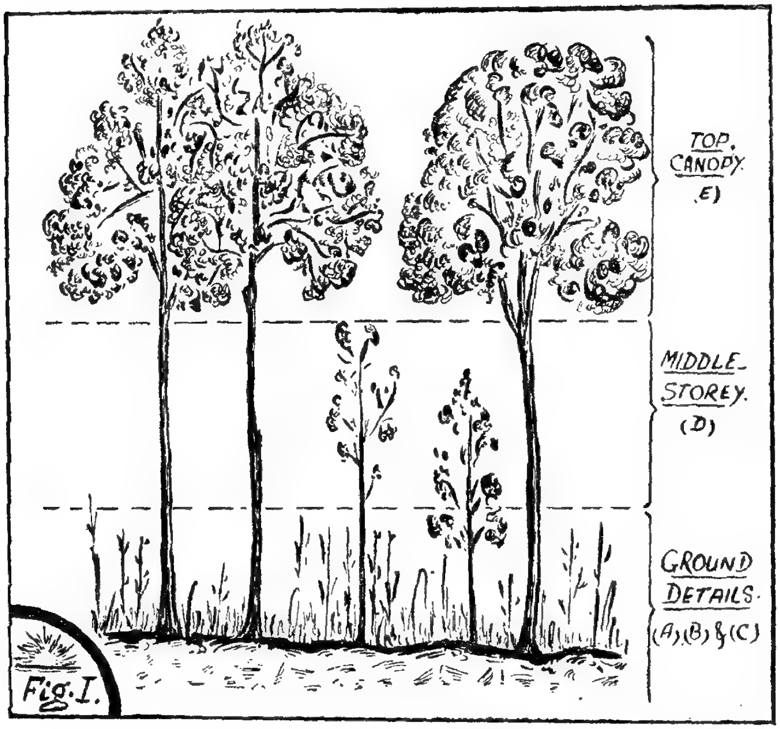


Fig. I.

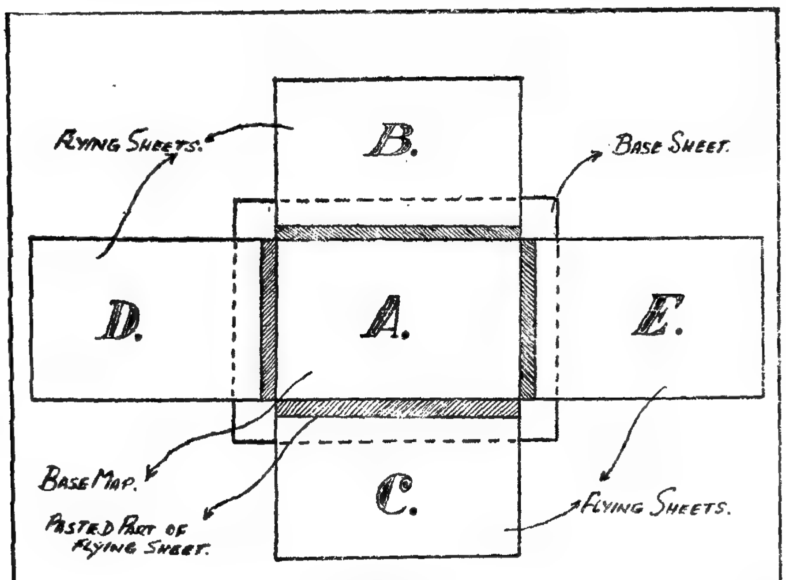


Fig. II.

The obvious objection which may be raised against the slicing of maps in this way is that the maps may tend to become cumbersome and the handiness which is a necessary requisite for such maps may ultimately be lost. This difficulty is, however, over-come by using the ordinary thick topographical map as the base and putting the other four maps of tracing cloth on it, each of which is pasted to the base map (A) on one side of it (see Fig. II).

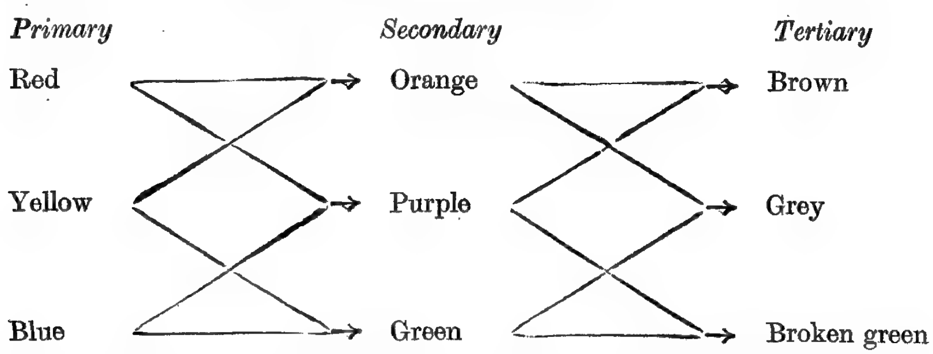
These four pasted sliced maps are the 'flying sheets'. Only the main topographical details are copied on them from the base map. Pasting is done in such a way that the topographical details on the flying sheets coincide with that of the base map, when the former is spread on the latter. The advantage of this system is that when one of the flying sheets is put on the base sheet, the vegetational and other details marked on the flying sheets may be correlated with the topographical details and other features marked on the base map. It is found convenient to show 'ground details', on sheets (A), (B) and (C), 'middle-storey details' on sheet (D) and 'top canopy details' on sheet (E).

Scale and size of maps—The regional vegetation maps, on small scales, are only of limited value. They, of course, give a bird-eye-view picture of the vegetation of a country but for intensive and extensive planning works which have become imperative during recent times, it is necessary to prepare vegetation maps on a sufficiently large scale, in such a way, that the handiness of these maps is not lost and at the same time as many details are shown on the map as possible.

Forest maps, in India, are mostly on $4'' = 1$ mile scale. This is found to be most convenient and is worth adoption. For some localities, $2'' = 1$ mile maps also exist. Although they have also proved fairly useful, they are not to be preferred. The size of one sheet of $4'' = 1$ mile map is usually 30×18 inches. In actual practice, it is found to be quite handy. Therefore, the $4'' = 1$ mile forest maps, as produced by the Survey Department in India, are quite suitable for the purpose of these sliced maps.

Choice of Colours—A pre-thoughtout colour-scheme for representing all details on various sheets of sliced maps is a great necessity. The main colours are as follows, and how they are formed is indicated by arrows :

CLASSIFICATION OF COLOURS



It is also convenient to use these colours or their various shades on different sheets, as follows :

Base Map ....Printed in black.

Ground details—Primary and secondary colours }
Sheet (A) – Red and blue and their various shades.
Sheet (B) – Yellow and purple and their various shades.
Sheet (C) – Orange and green and their various shades.

Middle storey —Tertiary colours } Sheet (D) – Grey and their various shades.

Top canopy —Tertiary colours } Sheet (E) – Brown and broken green and their various shades.

While adopting these colours, it should be remembered that most bright colours or shades should represent the most insignificant details, so that they may attract the eyes quickly and may not be lost sight of. Also, as far as possible, colours other than those mentioned above, should be avoided, as they create unnecessary confusion.

Choice of Symbols—When the same detail is to be represented over large continuous areas, it is best to use colour washes. The next best alternatives are to adopt cross-hatching, hatching by single lines or bands or their various modifications. When the details of sporadic occurrences are to be shown, it is desirable to adopt either the miniature geometrical figures or English and Greek alphabets of various colours. Black colour, however, is the one best suited for this purpose.

If colours other than black are used, there is possibility of confusion, as these symbols are usually super-imposed on the main washes or hatchings. To obviate this difficulty, contrasting colours should be used for them. The colour contrasts are as follows :

CONTRASTS OF COLOURS

Primary colours	Secondary colours in contrast to primary colours	Tertiary colours in contrast to secondary colours
Red ..	Green	Brown
Yellow ..	Purple	Grey
Blue ..	Orange	Broken green

Method of Survey—For the collection of detailed information, which is necessary for the preparation of sliced maps, Brandis' strip survey is most useful. In this method, the area is traversed back and forth in definite strips, which abut each other. The width of these strips may vary from one to four chains, depending on the density of the forest, which restricts the range of visibility. Such attempts were made by the writer in the Beechenhurst Block of the Forests of Dean in U.K. and in the sal forests of South Raipur Division (M.P.). The results obtained were most successful.

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PHENOLOGICAL BEHAVIOUR OF A FEW FOREST SPECIES AT NEW FOREST, DEHRA DUN

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SUMMARY

The Silviculture Branch of the Forest Research Institute, Dehra Dun, started an investigation in 1928 to study the phenological behaviour of some tree species growing at New Forest. Work under this investigation has so far been concluded on 17 species. The useful data have been analysed and the results given in the form of tables and graphs. In the case of four species, this information is available for crops of 12 different origins or varieties.

The comparative behaviours of the various species from the point of view of new leafing, leaf fall, deciduous or evergreen habits and the availability of ripe fruits or seeds have been studied. The main foliar renewal at New Forest takes place from the end of January, when the winter is still severe, till the end of May, which is the hottest part of the year, and does not appear to be materially influenced by the usual tendency on the part of vegetation to cut down moisture losses during the hot and dry period. None of the species completes leaf shedding before winter sets in. In most cases, the phytophase starts during February–March and is over by the end of April. The majority of the species examined in the present case are deciduous, three of them are clearly evergreen, while two lie on the border line. There is no universal leafless period at New Forest and it appears that the inherited traits are more powerful than the influence of the factors of locality. Most of the species flower during late winter and early summer, though a few also flower late during summer or during the monsoons. The flowering habits *vis-à-vis* new leafing and the presence or otherwise of leaves are also discussed. Most of these species produce ripe fruit in the premonsoon or early monsoon periods.

The factors governing the phenological and growth behaviours of plants have been discussed and the importance of the external factors has been pointed out. The climatic forces appear to be most important in controlling the variations in the time of occurrence of phenological phenomena. The previous work on the relationship between phenological and growth behaviours of tropical forest trees and the meteorological factors has been briefly reviewed. An attempt has been made to study the influence of variations in mean temperature, rainfall and humidity on fluctuations in leafing, flowering and fruit ripening of five of the species covered in this study. There is good evidence to believe that while fluctuations in dates of occurrence of the three phytophases under reference can in most cases be correlated with parallel changes in the main climatic forces, the measure and the direction of influence of the latter varies with the species and the phenomenon in question. Higher mean temperatures in the short period preceding the normal date of occurrence of the phenomenon tend to advance new leafing and flowering. Low rainfall and low relative humidity also appear to exercise a similar influence, though it may not be marked in some cases. Low temperatures, high rainfall and humidity have an opposite effect. High temperatures appear to quicken

fruit ripening in *Cedrela toona* and probably in *Shorea robusta* too. Heavy rainfall and high humidity also appear to advance fruit ripening in certain cases. This is in contrast with the influence of these two factors on new leafing and flowering where they show an opposite tendency. Fruit ripening in the case of *Dalbergia sissoo* and *Mangifera indica* does not show any clear relationship with temperature, rainfall or humidity.

2. INTRODUCTION

Phenological changes occurring in the surrounding flora have often attracted man's attention and very frequently agricultural practices have been correlated with these phenomena. Detailed and objective studies of the different phytophases, particularly in the case of forest trees have not, however, been initiated till recent times, though the seasonal changes in the case of the agricultural crops and the fruit trees must have been well observed ever since the dawn of civilization. The need for precise information about the phenological behaviour of the forest tree species came to be appreciated with the gradual development of the sciences of forestry and botany. Besides stimulating interest and improving habits of observation amongst the lovers of nature such information is of great practical value in a number of field operations. It helps the botanist in collecting plants in different stages of development and enables the forester correctly to time the various silvicultural operations such as seed collection, final fellings in high forest, coppice fellings, weedings, cleanings and improvement fellings, the different phases of nursery work and the successful introduction of exotics. Above all such detailed information gives an insight into the life activities of the plants and the mutual interaction of internal and external factors on plant life.

Our present sources of knowledge regarding the phenological behaviour of the Indian tree species are the numerous floras and works on silviculture along with other stray observations recorded by various foresters and lovers of nature. This information is mostly based on casual field observations, often made over a single or, at the most, a very small number of years and is invariably generalized for large tracts. The necessity for more dependable information, applicable to smaller localities has, therefore, been keenly felt.

The Silviculture Branch of the Forest Research Institute, Dehra Dun started a phenological project in 1928 with a view to devising suitable methods for carrying out the work on a large scale in the country and, in due course, to collect reliable information about the phenology of the various tree species at New Forest. As the work progressed, a number of modifications had to be introduced on the basis of experience gained, until, by 1931, the project assumed its present form. The project has remained on the active list of research items of the Silviculture Branch since then, and much useful information has been collected relating to a number of species. The object of this record is to describe the project, to study the phenological behaviours of the species on which observations have been concluded and to the extent possible, to attempt a correlation between climate and the various phytophases.

3. DESCRIPTION OF THE PROJECT

Observations have been taken on five normally developed trees of each species, a separate form being used for each tree. Care was taken to see that the selected trees were subject to normal conditions of growth in respect of soil fertility, availability of moisture and light, etc. While taking observations, the guiding principle has been to note the behaviour of the species as a whole, ignoring the erratic individuals. Similarly in the case of the individuals, the

behaviour of the tree as a whole and not of a few abnormal twigs was to be recorded. A selected tree noticed to behave markedly differently from others, was replaced by a normal one next year. Observations were recorded weekly during the periods of active change while at other times, they were taken at longer intervals. Where a change was noticed to have taken place during the interval between two visits, the inspecting officer gave an estimate of the actual date of occurrence.

The phytophases selected for observation are given below :—

1. beginning of new leafing ;
2. completion of new leafing ;
3. beginning of opening of flowers ;
4. maximum flowering ;
5. end of flowering ;
6. first ripe fruits ;
7. most or all fruits ripe ;
8. beginning of falling of seeds or fruits ;
9. most seeds or fruits fallen ;
10. all good seeds or fruits fallen ;
11. commencement of leaf fall ;
12. completion of leaf fall ;
13. commencement of elongation of terminal buds ;
14. commencement of appearance of new green needles ;
15. needles achieve full size ;
16. commencement of shrivelling of old needles ;
17. completion of shrivelling of old needles.

The first twelve items were meant for broad leaved species. As the changes in the foliage of conifers are more complicated and item numbers 1 and 2 cannot adequately cover them, they have been replaced by items 13 to 17.

4. LOCALITY AND ITS CLIMATE

Most of the trees selected for observation stand in the Demonstration Area of the Forest Research Institute, Dehra Dun. Some trees, however, have been taken from the Kaunli Garden, which was the old experimental area attached to the Institute, while the *Albizzia procera* trees and some of the *Salmalia malabarica* (local origin) trees are situated in the tea garden adjoining the Demonstration Area. These three areas form a compact circular block, nearly a mile and a half in diameter, and are situated in the Dehra Dun valley, about 3½ miles to the West of Dehra Dun town. The longitude and latitude of the locality are 78° 3′ E. and 30° 20′ N. respectively and it lies at about 2,200 feet above the mean sea-level.

Detailed information regarding rainfall and temperature at New Forest is given in the following statement.

TABLE 1.—*Average values of rainfall, mean daily temperature and humidity per cent at New Forest during the period 1929–45*

Month	Rainfall in inches	Mean temperature in degrees Fahrenheit	Humidity %*
January ..	2·7	51	79
February ..	2·3	55	76
March ..	1·3	64	62
April ..	0·9	73	48
May ..	1·7	81	43
June ..	8·1	81	61
July ..	26·1	78	85
August ..	26·8	77	89
September ..	11·3	75	82
October ..	1·3	69	68
November ..	0·1	61	66
December ..	1·2	54	75

Mean annual rainfall = 83·8 inches.

The comparatively light winter rains, coupled with the heavy dew-fall received at that time of the year play an important role and keep the humidity relatively high. Frosts are fairly common from late December to early February†. Being protected against the *loo* by the low Siwalik hills in the South and the West, the maximum temperature seldom rises beyond 105°F. during May and June.

5. WORK DONE SO FAR

The species on which observations have so far been concluded are shown in Table 2, which also gives the location of the experimental trees, their origin or variety and the period over which information has been collected in each case. Both exotic and indigenous species have been taken up, and wherever possible, different varieties or races of the same species have been noted on separately.

* Readings up to August, 1942 were taken at 8 a.m. while those from September, 1942 were taken at 10 a.m.

† The Doon Valley is reported to have experienced light snowfall twice or thrice since 1820. The last one was during January, 1945. For an authentic record see Note by A. L. Griffith at pages 117–118 of the *Indian Forester* of April, 1945.

TABLE 2.—*Species on which observations have been concluded up to 1950*

Serial No.	Species	Origin or variety	Locality where growing	Observations Started	Closed	Period in years	REMARKS
1	*Acacia catechu*, Willd. ..	Local	C. 10, Research Block, D.A.	1930	1947	18	1927 plantation.
	Do. ..	Burma	,, ,, ,,	1935	1935	1	,,
	Do. ..	Kanpur	C. 13, ,, ,,	1935	1944	10	,,
2	*Albizzia procera*, Benth. ..	Local	T.G. opposite C. 1 of Champion Block.	1929	1943	15	
3	*Salmalia malabarica* (D.C.) Schott & Endl. Syn., *Bombax malabaricum*, D.C.	Local	C. 10, Research Block, D.A., K.G. and T.G.	1932	1944	13	1927 plantation in the Research Block.
	Do. ..	Burma	C. 10, Research Block, D.A.	1935	1944	10	
4	*Broussonetia papyrifera*, Vent. ..	Unknown	C. 14, ,, ,,	1938	1947	10	
5	*Butea monosperma* (Lamk.) Kuntze Syn., *Butea frondosa*, Roxb.	Black	C. 7, ,, ,,	1933	1943	11	Seed of 1st two from Lansdowne division opposite Hardwar. All 1927 plantations.
	Do. ..	White	,, ,, ,,	1933	1943	11	
	Do. ..	Burma	C. 10, ,, ,,	1935	1937	3	
6	*Cedrela toona*, Roxb. ..	Local	K.G.	1928	1943	16	
7	*Celtis tetrandra*, Roxb. ..	Local	Along the main motor road in D.A.	1939	1947	9	
8	*Dalbergia latifolia*, Roxb. ..	Local	L. Block, K.G.	1928	1933	6	
9	*Dalbergia sissoo*, Roxb. ..	Local	,,	1928	1943	16	
10	*Syzygium cumini* (L.) Skeels Syn., *Eugenia jambolana*, Lam.	Local small seeded	New Forest Estate, outside the D.A.	1932	1943	12	
11	*Gmelina arborea*, Roxb. ..	Unknown	L. Block, K.G.	1928	1932	5	
	Do. ..	Buxa	C. 29, Teak Block, D.A.	1931	1931	1	1928 plantations.
	Do. ..	Burma	C. 27, ,, ,,	1931	1933	3	
	Do. ..	Madhya Pradesh	C. 30, ,, ,,	1931	1933	3	
	Do. ..	Chittagong	C. 32, ,, ,,	1931	1933	3	
	Do. ..	Coorg	C. 31, ,, ,,	1931	1933	3	

12	*Mangifera indica*, Linn. ..	Local ungrafted	North terrace of F.R.I. Main Building	1928	1943	16	
13	*Ougeinia dalbergioides*, Benth. ..	Local	C. 14, Research Block, D.A. and H. Block, K.G.	1934	1944	11	
14	*Pinus roxburghii*, Sargent Syn., *Pinus longifolia*, Roxb.	Unknown	H. Block, K.G.	1928	1943	16	Old trees.
	Do. ..	Chakrata	C. 23, Champion Block, D.A.	1931	1943	13	
	Do. ..	Local	C. 17, ,, ,,	1931	1943	13	
	Do. ..	Hazara	C. 44, ,, ,,	1931	1943	13	1926 plantations. The 'local' crop resulted from seed collected from trees growing locally whose exact origin was not known.
	Do. ..	Kangra	C. 21, ,, ,,	1931	1943	13	
	Do. ..	Lansdowne	C. 39, ,, ,,	1931	1943	13	
15	*Shorea robusta*, Gaertn. f. ..	Local	C. Block, K.G. and Research Block, D.A.	1929	1943	15	
16	*Tectona grandis*, Linn. f. ..	Unknown	C. 33, Teak Block and H. Block K.G.	1928	1947	20	
	Do. ..	Madhya Pradesh	C. 21, Teak Block, D.A.	1931	1933	3	1927 plantation.
	Do. ..	Burma	C. 24, ,, ,,	1931	1933	3	
	Do. ..	Nilambur	C. 39, ,, ,,	1931	1933	3	1929 plantations.
	Do. ..	Coorg	C. 40, ,, ,,	1931	1933	3	
17	*Terminalia tomentosa*, W. & A. ..	Local	C. 8, Research Block, D.A.	1930	1937	8	1927 plantation.

D.A. = Demonstration Area of the Forest Research Institute.
K.G. = Kaunli Garden, the old experimental area, before the acquisition of the New Forest Estate.
T.G. = Tea Garden adjoining the Demonstration Area.

TABLE 3.—*Dates of occurrence of the various phenological*

Serial No.	Species	DATE OF						
		Beginning of new leafing	Completion of new leafing	Beginning of opening of flowers	Maximum flowering	End of flowering	First ripe fruit	Most fruit ripe
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	*Acacia catechu* (Burma origin)	134* 118–146	201* 187–211	186* 166–230	202* 184–248	264* 210–300	..	..
2	*Acacia catechu* (local) ..	135† 105–154	193† 148–209	172† 158–201	188† 168–210	211† 190–228	317† 290–343	353† 325–31
3	*Albizzia procera* ..	122† 104–138	189† 153–208	217† 203–232	236† 208–253	258† 225–271	91† 79–117	108† 94–124
4	*Salmalia malabarica* (Burma origin)	107* 98–116	173* 155–211	80‖ 79–80	92‖ 90–93	104‖ 103–105	..	..
5	*Salmalia malabarica* (local)	91† 79–104	165† 126–204	27 18–47† 316 312–322	61† 46–74	80† 58–91	115† 105–129	127† 116–139
6	*Broussonetia papyrifera* ..	60* 54–67	117* 85–135	63§ 59–72	77§ 69–82	90§ 82–102	157* 150–166	181§ 163–196
7	*Butea monosperma* (black variety)	100* 84–112	139† 125–155	39‖ 7–70	73‖ 62–84	78‖ 81–92	..	..
8	*Butea monosperma* (white variety)	126* 106–153	168† 146–192	..	..	..	..	..
9	*Cedrela toona* ..	38‡ 24–48	99‡ 66–126	80‡ 68–95	101† 95–107	115† 106–124	133† 124–143	143† 113–158
10	*Celtis tetrandra* ..	64* 55–68	110§ 103–123	67§ 64–70	78§ 74–82	86§ 78–95	224* 210–242	270* 235–300
11	*Dalbergia latifolia* ..	118§ 94–126	172§ 158–183	..	..	..	..	..
12	*Dalbergia sissoo* ..	56‡ 46–69	108‡ 77–133	83‡ 64–99	99† 91–110	111† 103–120	311† 288–333	342† 328–359
13	*Syzygium cumini* ..	63† 47–72	128† 108–147	121† 85–139	141† 126–154	153† 135–164	178* 169–184	191* 183–197
14	*Gmelina arborea* ..	86§ 66–100	146§ 125–196	81§ 66–85	95‖ 92–98	118‖ 116–120	141‖ 137–143	159§ 151–164
15	*Mangifera indica* ..	88‡ 73–130	162‡ 107–215	68‡ 43–82	92† 80–101	108† 93–118	183† 161–194	202† 184–220
16	*Ougeinia dalbergioides* ..	145† 136–159	189† 156–213	65* 56–76	77* 70–85	90* 80–96	124* 118–131	135* 129–146
17	*Pinus roxburghii* (unknown origin)	..	..	29‡ 4–54	57† 40–74	112† 81–125	353* 339–364	72* 62–79
18	*Pinus roxburghii* (Chakrata origin)	..	..	..	..	..	..	..

phenomena for some tree species at New Forest

OCCURRENCE OF

Beginning of falling fruits or seed	Most fruits or seeds fallen	All good seeds or fruits fallen	Leaf fall starts	Leaf fall over	Beginning of elongation of buds	Beginning of appearing of new needles	Needles full sized	Beginning of shrivelling of old needles	Completion of shrivelling of old needles
(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
..	..	..	65* 12–101	123* 95–139	..	..	..	..	..
38† 350–99	113* 74–148	129† 78–156	69† 41–96	126† 107–140	..	..	..	..	..
100† 90–120	121† 102–134	133† 105–147	34† 358–78	114† 77–126	..	..	..	..	..
..	..	..	29* 3–49	91* 81–104	..	..	..	..	..
124† 112–133	135† 122–147	144† 127–151	343† 338–25	45† 12–87	..	..	..	..	..
162§ 154–170	182* 166–200	191* 173–203	334* 321–348	32* 27–40	..	..	..	..	..
..	..	..	43* 16–74	89* 65–106	..	..	..	..	..
..	..	..	93§ 23–127	121* 75–151	..	..	..	..	..
136‡ 126–146	147† 136–159	155‡ 143–171	329‡ 310–358	28‡ 12–48	..	..	..	..	..
245§ 219–290	299§ 279–318	333§ 311–354	318§ 266–341	28§ 14–41	..	..	..	..	..
..	..	..	75§ 55–87	122§ 111–130	..	..	..	..	..
37† 7–80	92* 49–122	107† 68–135	328‡ 312–347	36† 14–60	..	..	..	..	..
181* 171–188	194* 184–201	199* 190–205	45† 25–64	108† 92–119	..	..	..	..	..
145§ 138–152	..	165§ 163–169	6‖ 4–9	93§ 89–100	..	..	..	..	..
187† 165–198	..	209† 191–223	45‡ 5–94	139‡ 100–180	..	..	..	..	..
131* 123–136	143* 132–151	148* 145–153	89† 61–121	139† 124–152	..	..	..	..	..
114† 94–126	135† 114–145	145* 125–155	87‡ 62–116	153‡ 141–170	7* 358–29	65* 56–79	200* 185–211	69* 29–92	129* 116–145
..	..	..	75† 40–95	142† 128–165	33* 1–41	63† 57–69	201* 188–211	353† 332–9	114† 103–132

(contd.)

Table 3.—*Dates of occurrence of the various phenological*

Serial No.	Species	Date of						
		Beginning of new leafing	Completion of new leafing	Beginning of opening of flowers	Maximum flowering	End of flowering	First ripe fruit	Most fruit ripe
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
19	*Pinus roxburghii* (local)	..	..	..	..	..	..	..
20	*Pinus roxburghii* (Hazara origin)	..	..	..	..	..	..	..
21	*Pinus roxburghii* (Kangra origin)	..	..	..	..	..	..	..
22	*Pinus roxburghii* (Lansdowne origin)	..	..	..	..	..	..	..
23	*Shorea robusta* ..	90† 63–116	161† 111–208	85† 69–103	104† 84–117	121† 110–132	158† 149–169	170† 161–177
24	*Tectona grandis* (unknown origin)	144‡ 115–153	189‡ 159–209	223‡ 185–247	245‡ 217–285	268‡ 235–325	352† 317–14	37‡ 6–69
25	*Terminalia tomentosa* ..	123§ 107–141	215§ 187–240	..	..	..	..	..

INDEX:

* Observations taken over a period of 8 to 10 years.
† Observations taken over a period of 11 to 14 years.
‡ Observations taken over a period of 15 years and above.
§ Observations taken over a period of 5 to 7 years.
|| Observations taken over a period of less than 5 years.

phenomena for some tree species at New Forest—(concld.)

OCCURRENCE OF

Beginning of falling fruits or seed	Most fruits or seeds fallen	All good seeds or fruits fallen	Leaf fall starts	Leaf fall over	Beginning of elongation of buds	Beginning of appearing of new needles	Needles full sized	Beginning of shrivelling of old needles	Completion of shrivelling of old needles
(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
..	..	..	93† 82–108	151† 137–175	35* 25–40	62† 56–65	200* 187–212	7* 337–56	128* 108–150
..	..	..	88† 34–112	149* 130–165	35* 24–42	64† 59–67	202* 189–211	358* 339–36	122* 108–137
..	..	..	88† 60–102	150† 132–173	37* 28–46	63† 57–67	202* 188–213	357† 342–11	121† 107–139
..	..	..	93† 80–107	152† 134–171	34* 17–44	64† 58–67	202* 187–212	31* 9–76	123* 114–139
162† 154–171	174† 164–183	179† 166–190	69† 56–83	123† 97–163	..	..	..	..	..
53† 12–94	81† 46–116	118‡ 78–142	82‡ 68–106	135‡ 108–155	..	..	..	..	..
..	..	..	60‖ 52–75	112‖ 104–117	..	..	..	..	..

Broussonetia papyrifera, Dalbergia latifolia, Gmelina arborea, Pinus roxburghii and *Tectona grandis* are exotics to Dehra Dun, and, like a number of other species, have been introduced comparatively recently. Out of these *Dalbergia latifolia, Gmelina arborea* and *Tectona grandis* failed in most cases for a variety of reasons, the most important probably being damage from frost. *Broussonetia* and *Pinus roxburghii* on the other hand, have succeeded very well. Due to its frost hardy nature, extremely fast growth rate, capacity to shoot up even under adverse light conditions and the remarkable ease with which it regenerates itself both vegetatively and from seed, *Broussonetia* has already obtained a strong foot-hold in the locality and is fast spreading. *Pinus roxburghii* occurs naturally at elevations of about 2,500 feet and above, along the Siwalik ridge to the South and West and on the Himalayas to the North and East of the main valley. The conditions are quite favourable for its artificial propagation in the New Forest Estate and Kaunli Garden, where the species has shown an exceptionally fast growth rate.

As recorded in Table 2, the period of observation for various species has varied from 1 to 20 years. The reason for discontinuing the observations on *Acacia catechu* (Kanpur origin), *Butea monosperma* (Burma origin), *Gmelina arborea* (Buxa, Burma, Madhya Pradesh, Chittagong and Coorg origins) and *Tectona grandis* (Madhya Pradesh, Burma, Nilambur and Coorg origins) within 3 years of their being started was the disappearance of the crops under observation. The differences in the remaining cases are presumably due to lack of clear prescriptions about the period for which observations were to be taken in each case. It has also not been possible to collect information about all the phenomena for each species because some of these – e.g., *Acacia catechu* of Burma origin, *Pinus roxburghii* of Chakrata, local, Hazara, Kangra and Lansdowne origins, *Salmalia malabarica* of Burma origin, *Butea monosperma*, both black and white varieties, *Dalbergia latifolia* and *T. tomentosa* – were too young to flower or/and fruit.

6. COMPUTATIONS AND THE TIME OF OCCURRENCE OF DIFFERENT PHYTOPHASES AT DEHRA DUN

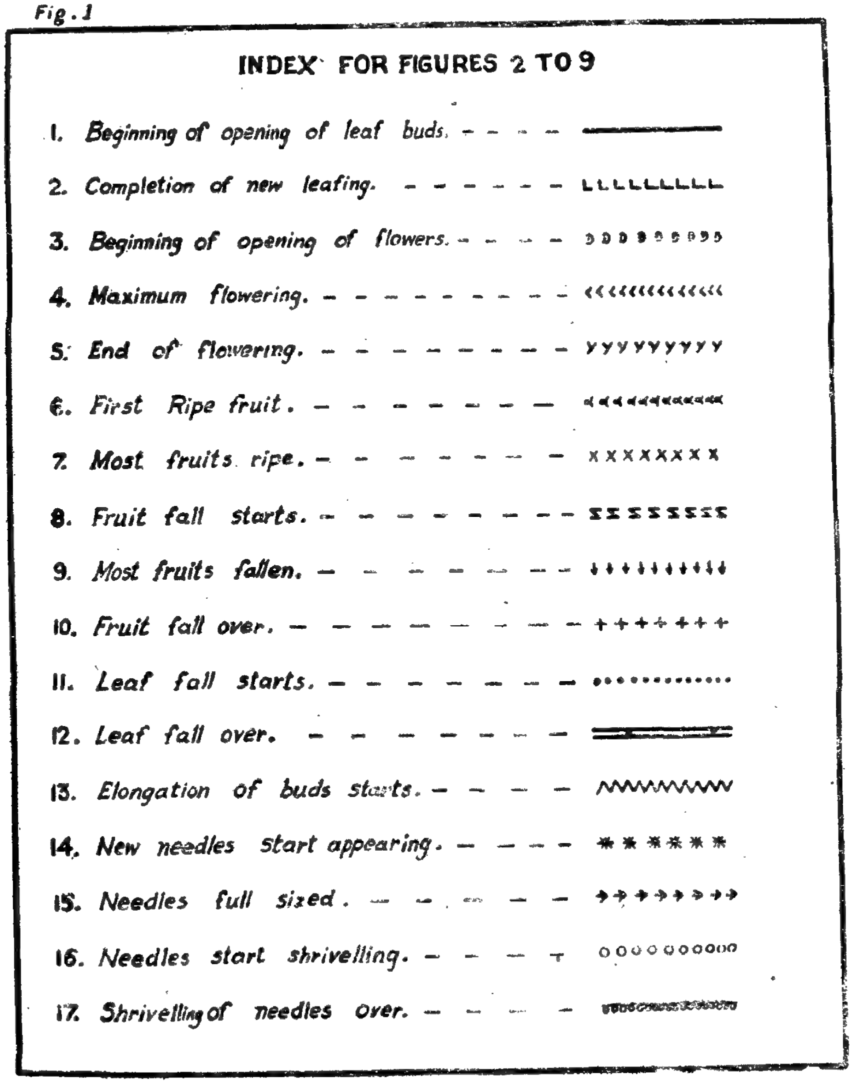
The recorded data have been carefully examined to judge their suitability for yielding reliable information about the phenological behaviour of the species under consideration. The species on which work was discontinued after 1 to 3 years have been rejected because the selected individuals progressively died out, so that the data in addition to covering only very short periods are also very meagre.

The actual computations for the remaining cases have been carried out in two stages. The average date of occurrence of a particular phenomenon was first determined for each year. While doing so the obviously abnormal individual values were rejected. This has been done because the chief object of the investigation is to find out the phenological behaviour of the species as a whole and the inclusion of erratic individuals is bound to vitiate that object. The final average values were then determined from these annual averages. In order to facilitate the work the dates have been converted into absolute numbers taking 1st of January as 1 and 31st of December as 365 and have been expressed in this form throughout. Thus 5th January and 5th March have been expressed as 5 and 64 respectively. The final results are summarized in Table 3 which gives for each species the average date of occurrence of each phenomenon, the range over which it may be usually seen and the period of years over which the observations were recorded. The range of occurrence is based on the annual means and not on the observations from individual trees. It is to be emphasized that this statement only gives average dates for the species as whole. As the abnormal individuals have been left out of consideration throughout, exceptions in the case of such individuals are to be expected and will often be met with in the field. Mention may also be made about the subsidiary flushes of new leaves, especially in the case of evergreens like *Mangifera indica*. Only the first main spurt of foliar renewal has been noted in all cases.

7. DIAGRAMMATIC REPRESENTATION OF THE PHENOLOGY OF VARIOUS SPECIES

The information contained in the above statement has been utilized in preparing Figs. 1 to 9 which give a diagrammatic representation of the phenological behaviour of various species. In addition to showing the average dates and ranges of occurrence of various phenomena the graphs also give the time taken by each species to complete one full cycle of leafing, flowering and fruiting.

Fig. 1



8. COMPARISON OF THE PHENOLOGICAL BEHAVIOURS OF THE VARIOUS SPECIES

A study of Table 3 and the subsequent 9 diagrams throws interesting light on the comparative phenological behaviour of the species under discussion. The subject can be viewed from a number of angles and some of the salient points have been touched upon briefly in the following paragraphs.

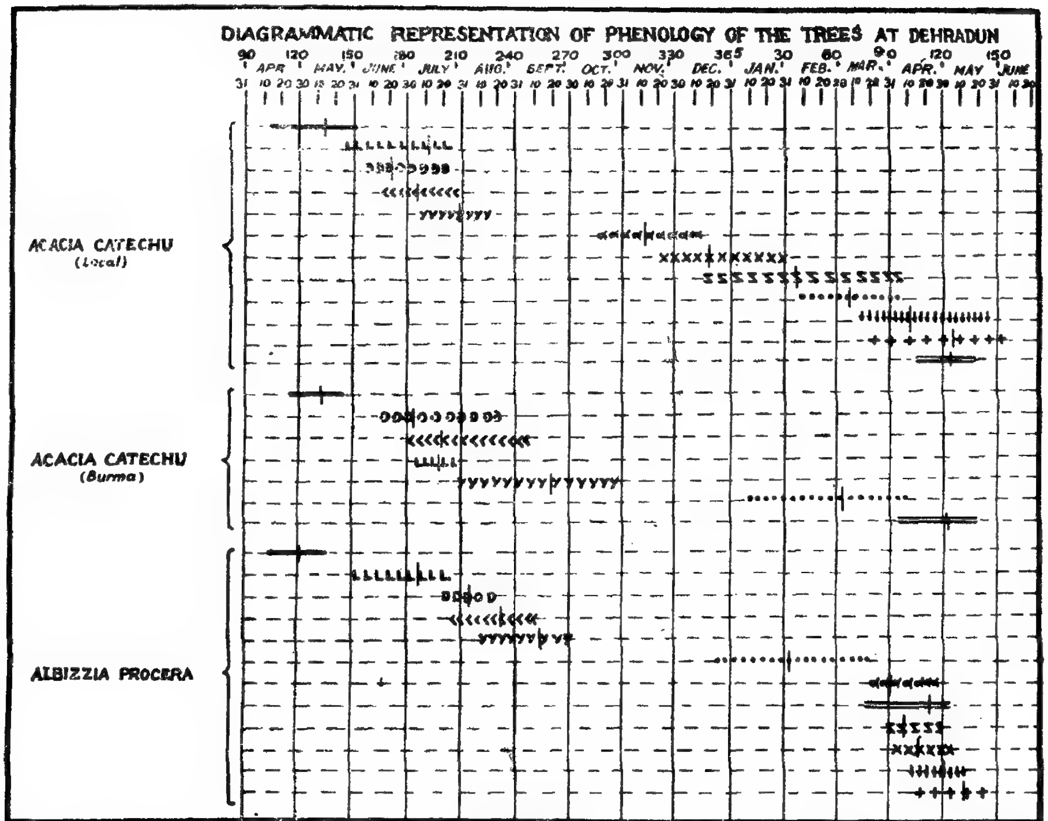
(*a*) *New Leafing*—Table 4 below, based on Table 3, gives for each species the earliest and the normal dates on which new leafing begins, the normal and the latest dates on which it is completed and the period over which it normally lasts*. It thus shows normal and the maximum ranges of occurrence of the phenomenon.

TABLE 4.—*Period of new leafing for different tree species at New Forest*

Serial No.	Species	Date on which new leafing commences		Date of completion of new leafing		Period in days over which new leafing normally lasts
		Earliest observed	Average	Average	Latest observed	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	*Acacia catechu* (Burma) ..	118	134	201	211	67
2	*Acacia catechu* (local)	105	135	193	209	58
3	*Albizzia procera*	104	122	189	208	67
4	*Salmalia malabarica* (Burma) ..	98	107	173	211	66
5	*Salmalia malabarica* (local) ..	79	91	165	204	74
6	*Broussonetia papyrifera*	54	60	117	135	57
7	*Butea monosperma* (black variety) ..	84	100	139	155	39
8	*Butea monosperma* (white variety) ..	106	126	168	192	42
9	*Cedrela toona*	24	38	99	126	61
10	*Celtis tetrandra*	55	64	110	123	46
11	*Dalbergia latifolia*	94	118	172	183	54
12	*Dalbergia sissoo*	46	56	108	133	52
13	*Syzygium cumini*	47	63	128	147	65
14	*Gmelina arborea*	66	86	146	196	60
15	*Mangifera indica*	73	88	162	215	74
16	*Ougeinia dalbergioides*	136	145	189	213	44
17	*Pinus roxburghii* (unknown origin, in Kaunli Garden)	56	65	200	211	135
18	*Shorea robusta*	63	90	161	208	71
19	*Tectona grandis*	115	144	189	209	45
20	*Terminalia tomentosa*	107	123	215	240	92

* As already mentioned the above account ignores the subsidiary flushes of foliar production which are common especially in the case of evergreen species like *Mangifera indica*.

Fig. 2



Note:- For Index please refer to Fig. 1.

Fig. 3

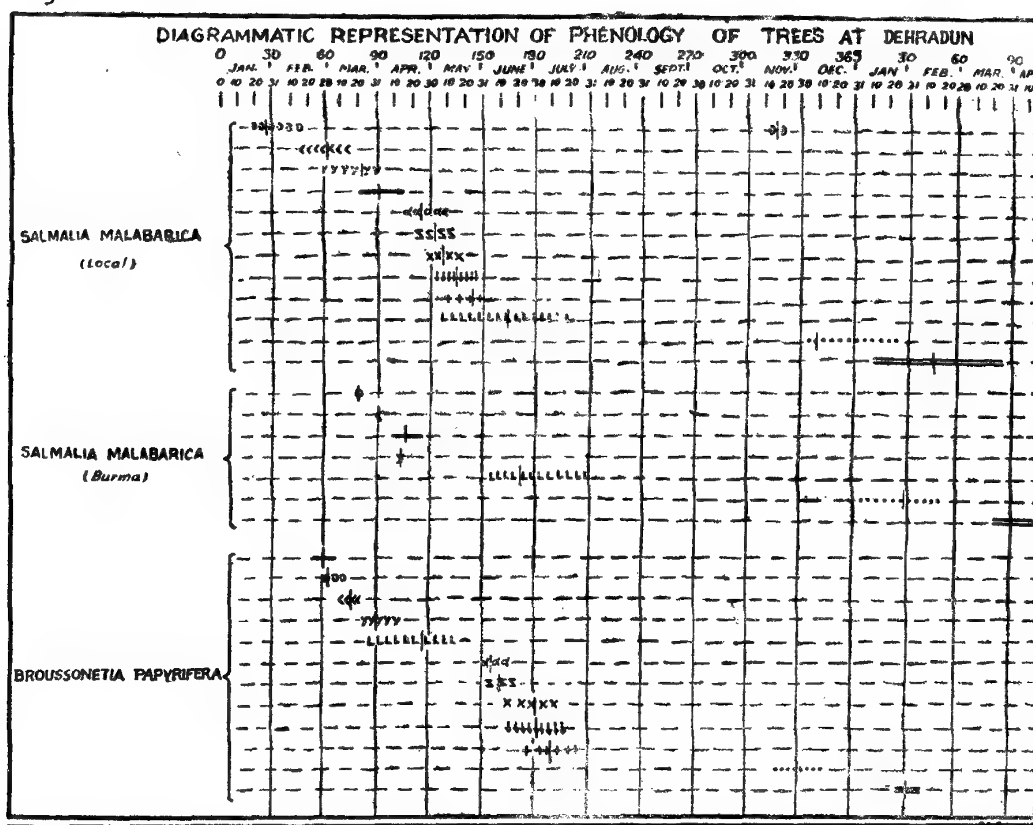
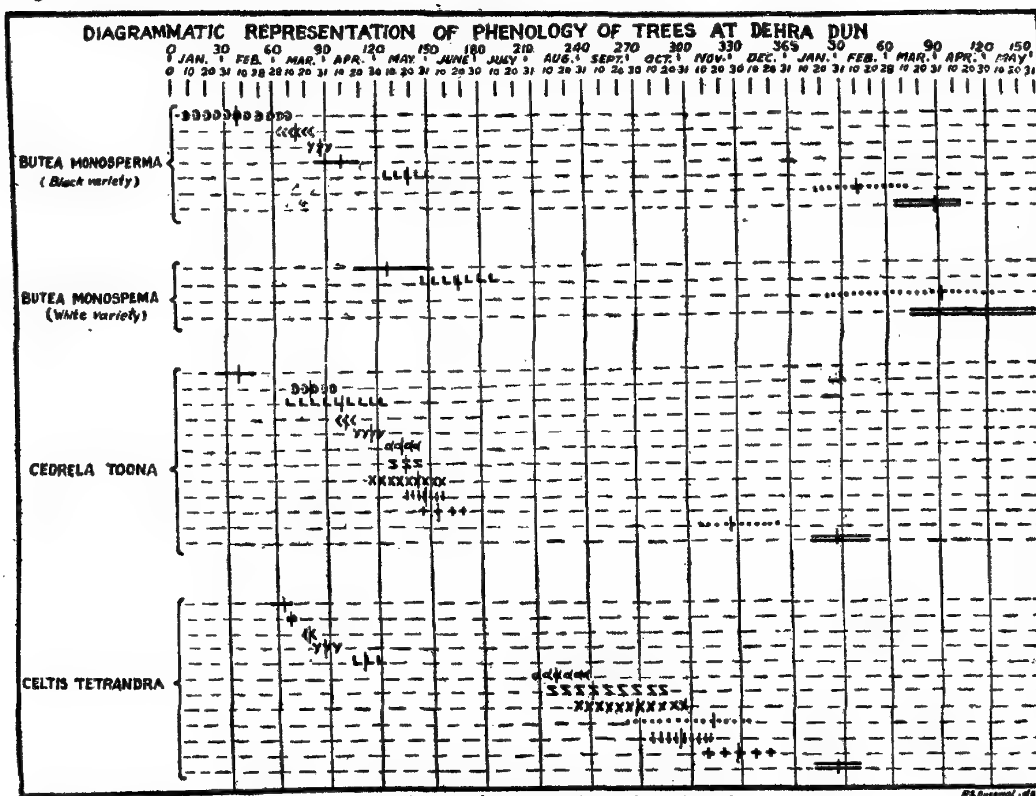
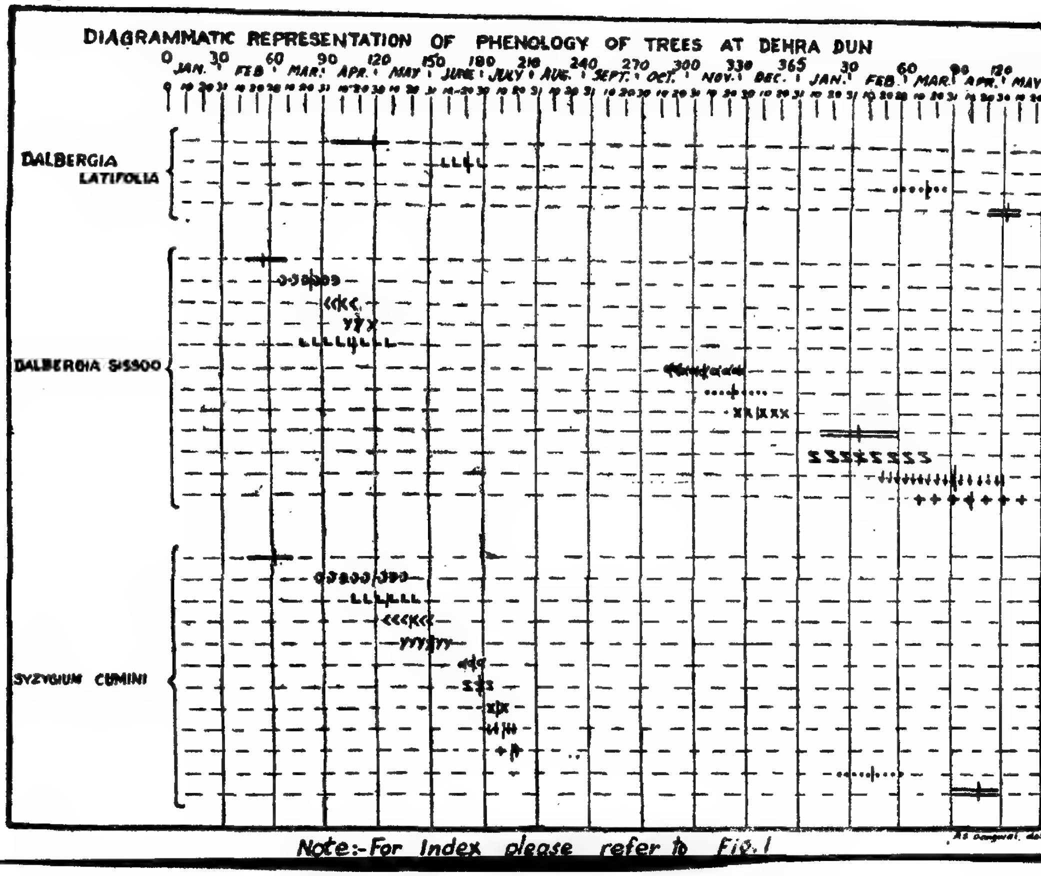


Fig. 4



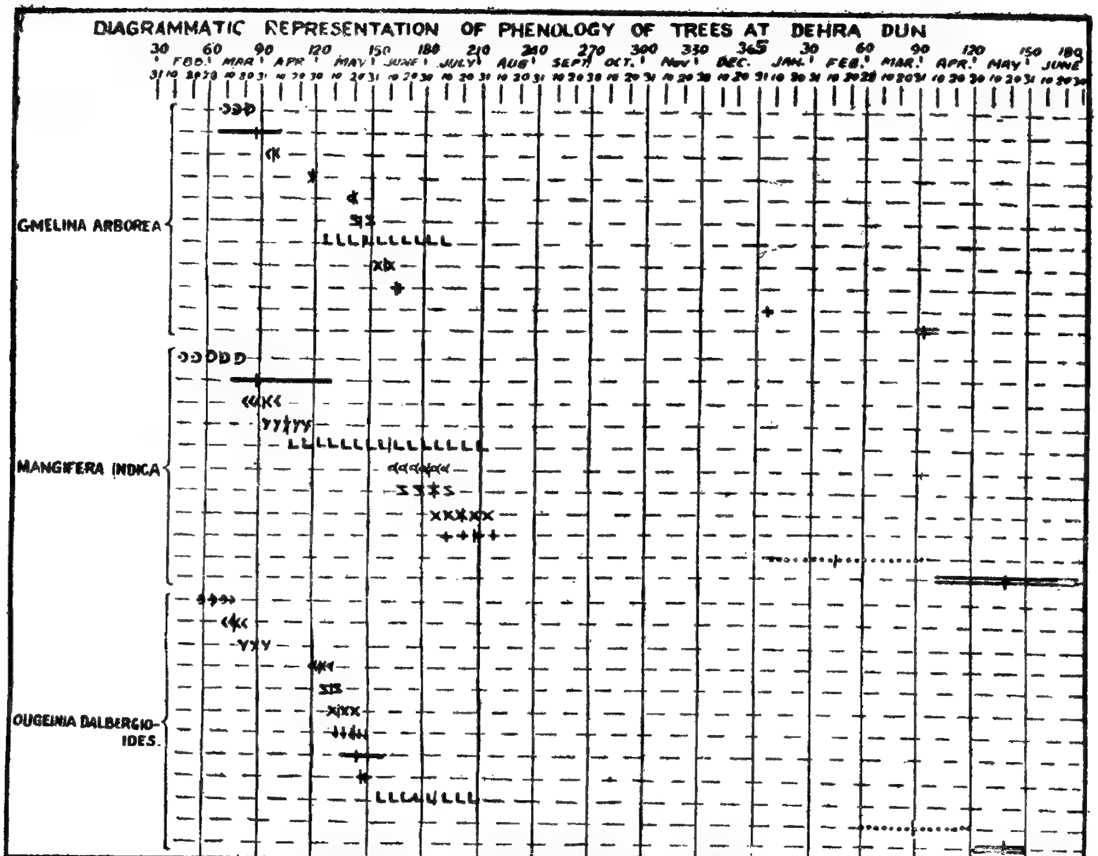
Note:- For Index please refer to Fig. 1

Fig. 5



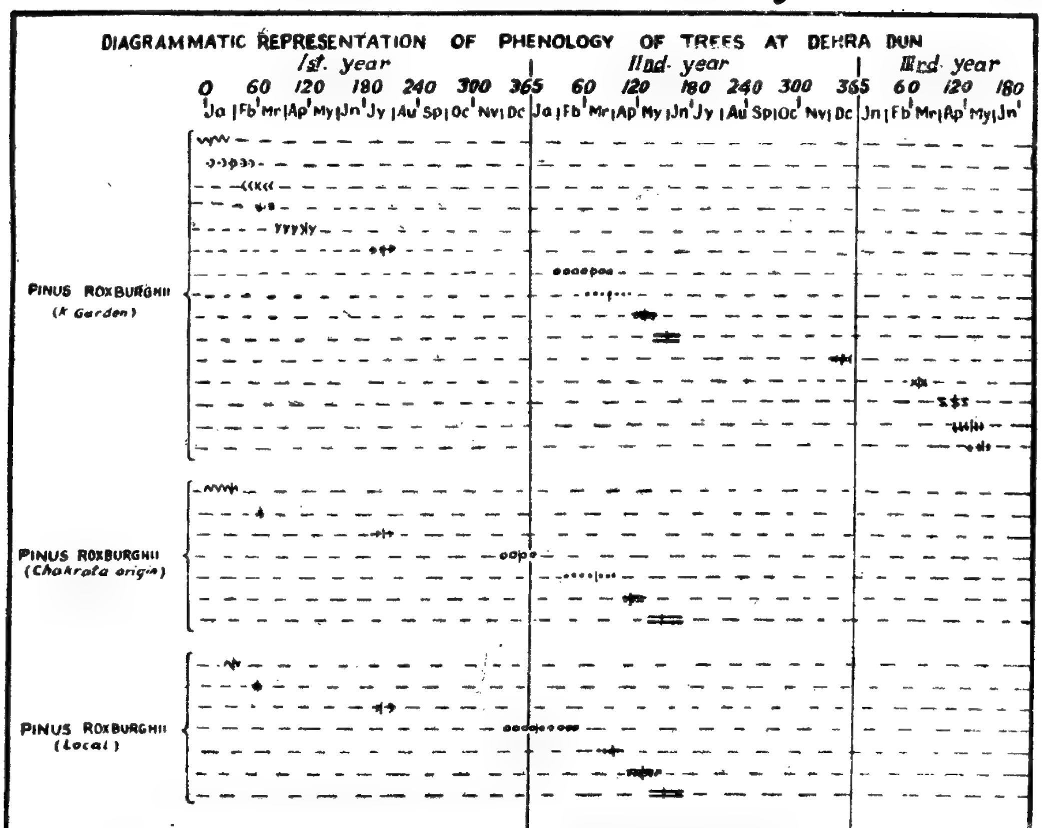
Note:- For Index please refer to Fig. 1

Fig. 6.



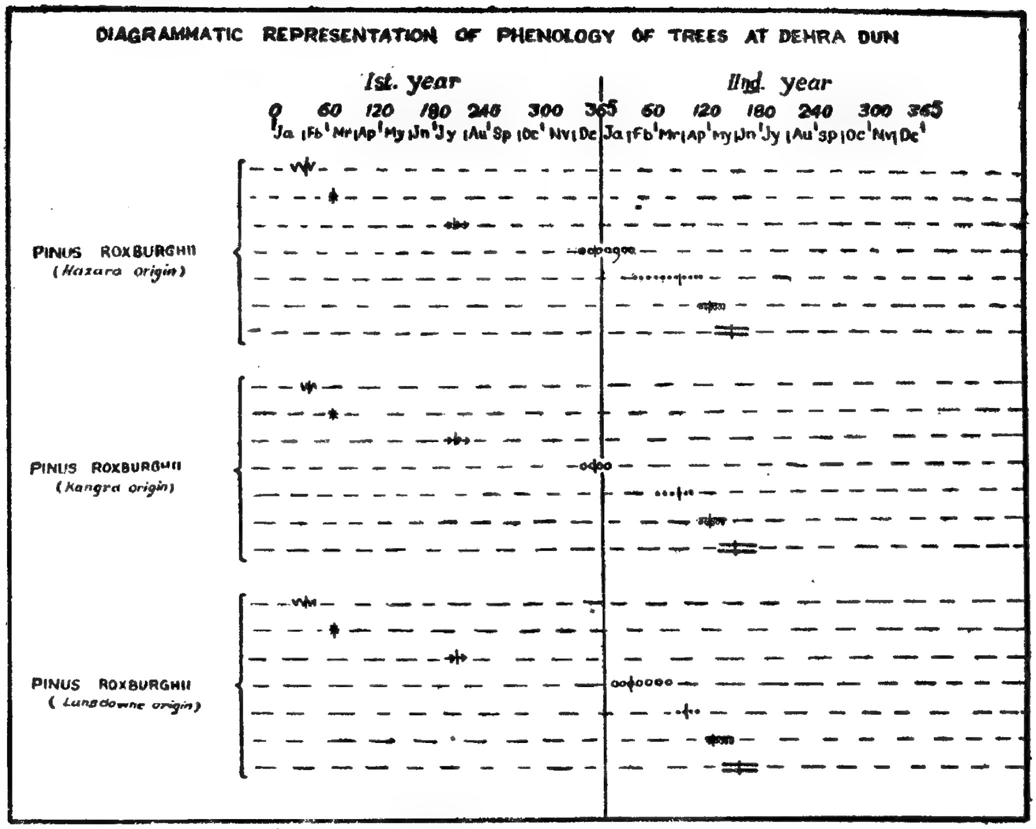
Note:- For Index please refer to Fig. 1.

Fig. 7.



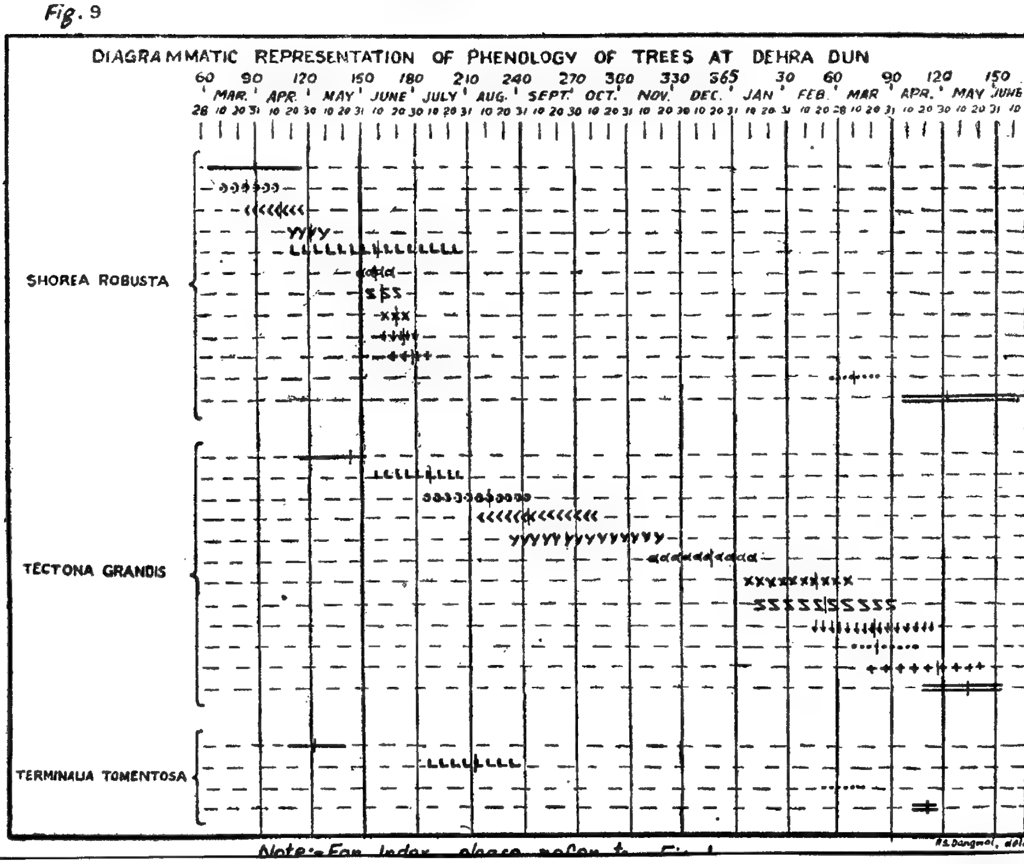
Note:- For Index please refer to Fig. 1.

Fig. 8



Note:- For Index please refer to Fig. 1.

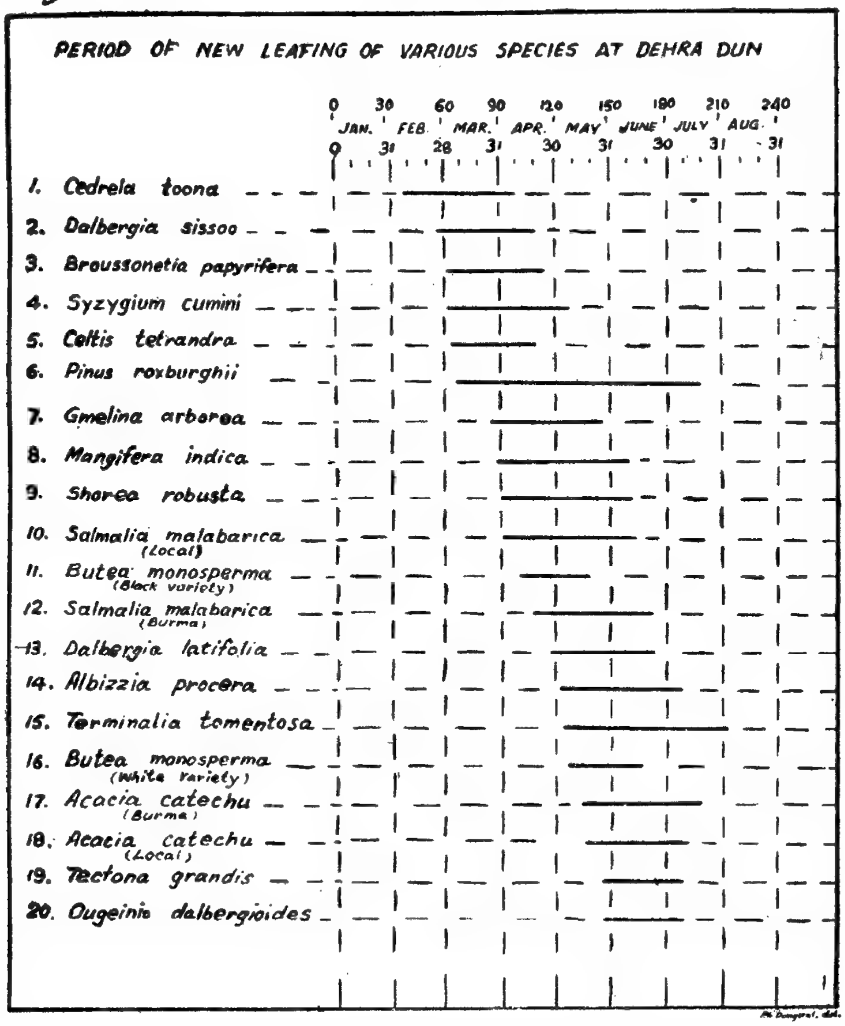
Fig. 9



Note:- For Index please refer to Fig. 1.

Fig. 10 shows graphically the chronological order in which the phenomenon progresses.

Fig. 10



It will be readily seen that the species under consideration do not exhibit any regular pattern from the point of view of the time of starting and completion of the phenomenon and its absolute duration. New leaves at New Forest may start appearing any time towards the end of January, when the winter has not lost its severity, to the end of May, which is the hottest and driest period of the year. Major part of the foliar repletion is, however, completed in all the cases before the summer rains start towards the end of June or the beginning of July. *The phenomenon is thus not materially influenced by any urge on the part of the species to reduce moisture losses due to transpiration during the dry period.*

The species may be roughly divided into 3 groups. Some like *Cedrela toona, Dalbergia sissoo, Broussonetia papyrifera, Syzygium cumini,* and *Celtis tetrandra* complete the process mainly during what may be termed as the spring season. Others such as *Salmalia malabarica* of Burma origin, *Dalbergia latifolia, Albizzia procera, Terminalia tomentosa, Butea monosperma* white variety, *Acacia catechu, Tectona grandis* and *Ougeinia dalbergioides* put on new leaves

chiefly during summer. The remaining ones, excepting for *Pinus roxburghii* form the intermediate group. The pine is a case apart as it normally starts putting on leaves towards the beginning of March and continues doing so till the later part of July. In all cases the major part of new leafing is over before the setting in of the summer rains in the last week of June.

The absolute duration of the phenomenon varies from 39 days in the case of *Butea monosperma* (black variety) to 135 days in that of *chir* pine. Practically all the broad leaved trees under study complete the phytophase in about 2½ months time while *chir* takes 4½ months to do so.

It may also be noted that different origins or varieties of *Acacia catechu*, *Salmalia malabarica* and *Butea monosperma* growing at New Forest have exhibited differences in the matter of foliar renewal. New leafing starts practically simultaneously in the case of *Acacia catechu* crops of local and Burma origins, but the latter takes 8 days longer to complete the phase. *Salmalia malabarica* of local origin starts putting on new leaves some 16 days earlier than trees of the Burma origin and completes the phase 8 days earlier. The black variety of *Butea monosperma* starts foliar production 26 days earlier and completes the phase 29 days earlier than the white variety. On the other hand, new needles are produced at practically the same time in the case of *chir* crops of different origins.

(*b*) *Leaf fall*—The earliest and the average dates of commencement of leaf fall, the average and the latest dates of completion of the phenomenon as well as the normal period over which it extends are given in Table 5. These data have been employed in preparing Fig. 11.

Fig. 11

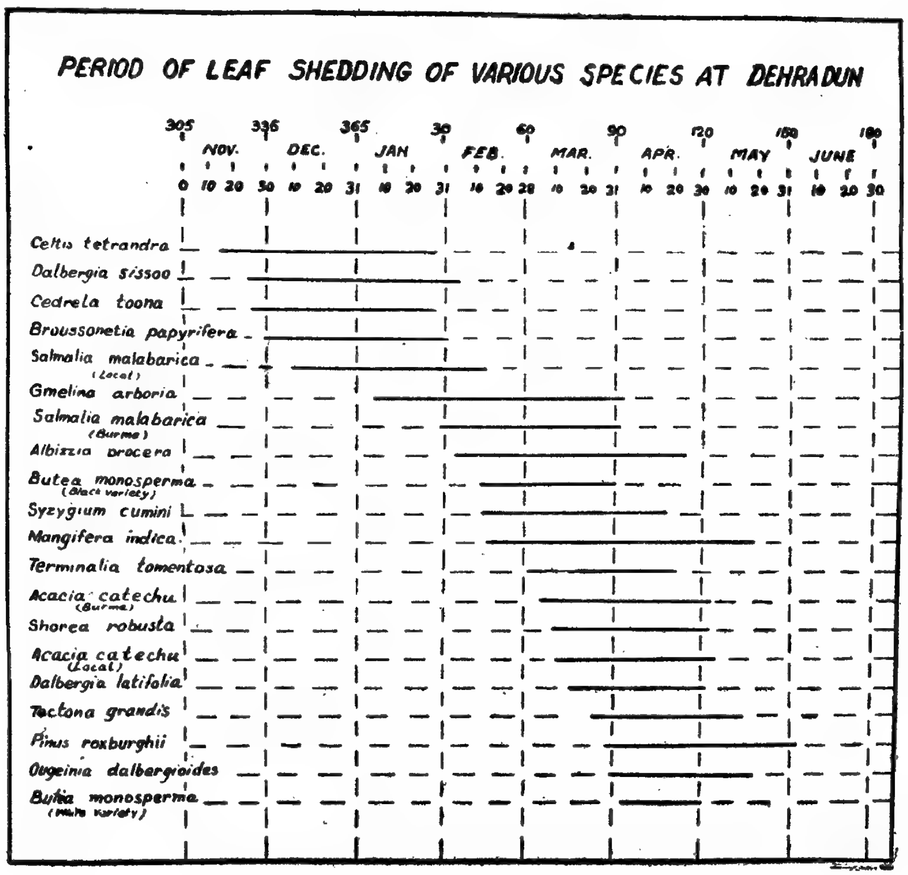


TABLE 5.—*Period of leaf fall for different tree species at New Forest*

Serial No.	Species	Date of commencement of leaf fall		Date of completion of leaf fall		Normal period of leaf shedding in days
		Earliest observed	Average	Average	Latest observed	
1	*Acacia catechu* (Burma origin) ..	12	65	123	139	58
2	*Acacia catechu* (local)	41	69	126	140	57
3	*Albizzia procera*	359	34	114	126	80
4	*Salmalia malabarica* (Burma origin)	3	29	91	104	62
5	*Salmalia malabarica* (local) ..	338	343	45	87	67
6	*Broussonetia papyrifera*	321	334	32	40	63
7	*Butea monosperma* (black variety) ..	16	43	89	106	46
8	*Butea monosperma* (white variety) ..	23	93	121	151	28
9	*Cedrela toona*	310	329	28	48	64
10	*Celtis tetrandra*	266	318	28	41	75
11	*Dalbergia latifolia*	55	75	122	130	47
12	*Dalbergia sissoo*	312	328	36	60	73
13	*Syzygium cumini*	25	45	108	119	63
14	*Gmelina arborea*	4	6	93	100	87
15	*Mangifera indica*	5	45	139	180	94
16	*Ougeinia dalbergioides*	61	89	139	152	50
17	*Pinus roxburghii*	62	87	153	170	66
18	*Shorea robusta*	56	69	123	163	54
19	*Tectona grandis*	68	82	135	155	53
20	*Terminalia tomentosa*	52	60	112	117	52

It may be observed that none of the species gets completely defoliated before the winter sets in. *Celtis tetrandra*, *Dalbergia sissoo*, *Cedrela toona*, *Broussonetia papyrifera* and *Salmalia malabarica* start shedding the old leaves during early winter but the phase is not completed before the end of January by which time the mean temperatures start showing an upward trend. The phenomenon in majority of cases starts during February–March and is over by the end of April.

As in the case of foliar production, differences in origin or variety of species have resulted in differences in the dates of occurrence of this phytophase as well. These differences are particularly marked in *Salmalia malabarica* of local and Burma origins and the black and white varieties of *Butea monosperma*. In the case of *Salmalia malabarica* of local origin, leaf fall normally lasts for 67 days from 8th of December to 14th February, whereas it starts on 29th January in the case of trees of Burma origin and is over on 1st April after a period of

62 days. The differences are still more marked in the case of *Butea monosperma* : the duration of this phytophase for the black variety being 46 days (12th February to 30th March) and only 28 days (3rd April to 1st May) for the white variety. Out of the different origins of *chir* under observation in the present case, the Chakrata origin crops shed their old needles considerably earlier than the rest.

The absolute duration of this phase varies from 28 days in the case of *Butea monosperma*, white variety, to 94 days for *Mangifera indica* : most of the species taking about 50–60 days.

(*c*) *Deciduous and evergreen habits*—The average dates of completion of leaf fall and the beginning of new leafing, as well as the average duration of the leafless period for the various species are shown in Table 6.

TABLE 6.—*Periods during which the various species are leafless at New Forest*

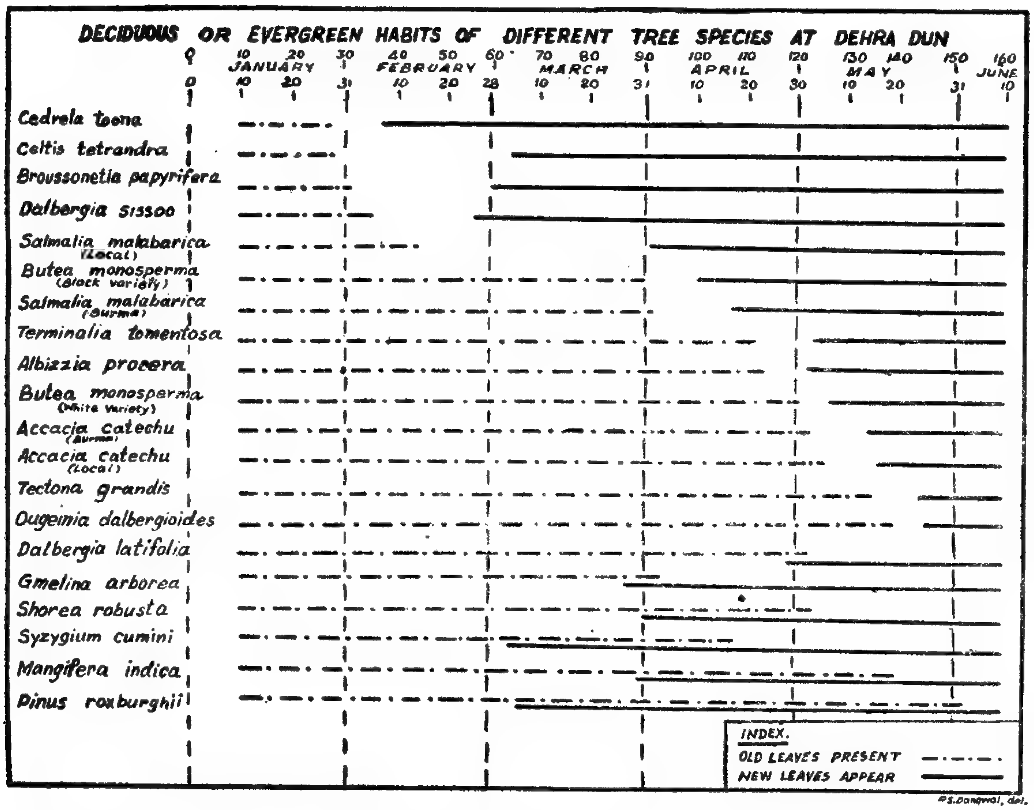
Serial No.	Species	Average date of completion of leaf fall	Average date of beginning of opening of leaf buds	Average leafless period in days	Remarks
1	*Acacia catechu* (Burma origin) ..	123	134	11	
2	*Acacia catechu* (local origin) ..	126	135	9	
3	*Albizzia procera*	114	122	8	
4	*Salmalia malabarica* (Burma origin)	91	107	16	
5	*Salmalia malabarica* (local origin) ..	45	91	46	
6	*Broussonetia papyrifera*	32	60	28	
7	*Butea monosperma* (black variety) ..	89	100	11	
8	*Butea monosperma* (white variety) ..	121	126	5	
9	*Cedrela toona*	28	38	10	
10	*Celtis tetrandra*	28	64	36	
11	*Dalbergia latifolia*	122	118	– 4	
12	*Dalbergia sissoo*	36	56	20	
13	*Syzygium cumini*	108	63	–45	
14	*Gmelina arborea*	93	86	– 7	
15	*Mangifera indica*	139	88	–51	
16	*Ougeinia dalbergioides*	139	145	6	
17	*Pinus roxburghii*	153	65	–88	
18	*Shorea robusta*	123	90	–33	
19	*Tectona grandis*	135	144	9	
20	*Terminalia tomentosa*	112	123	11	

The negative values of the leafless period in the cases of *Dalbergia latifolia, Gmelina arborea, Shorea robusta, Syzygium cumini, Mangifera indica* and *Pinus roxburghii* indicate that new leafing in their cases starts before the old leaves have fallen and that normally these species are not entirely leafless at any stage at New Forest. Out of these, *Dalbergia latifolia* and *Gmelina arborea* are on the border line and are commonly regarded as deciduous. During years of unfavourable climatic conditions, most of the trees of these species remain leafless for short periods, while under favourable conditions they retain a small proportion of their old foliage till the appearance of the new flush. Thus in both cases they give an impression of being totally deciduous or at the most having very few leaves. A graphical representation of the phenomenon has been shown in Fig. 12 where the species have been arranged in the chronological order of the leafless period or the absolute length of the period during which the old and new leaves occur side by side.

Majority of the tree species considered here are deciduous. The length of the average leafless period varies from 46 days in the case of *Salmalia malabarica* (local origin) to only 5 days with *Butea monosperma* (white variety). The deciduous species may be roughly divided into two groups. The first group consists of the early deciduous ones such as *Cedrela*

toona, Celtis tetrandra, Broussonetia papyrifera, Dalbergia sissoo and *Salmalia malabarica* (local variety) which are leafless in February or February–March. The second group is leafless during April and May and is comprised of *Butea monosperma* (black and white varieties), *Salmalia malabarica* (Burma origin), *Terminalia tomentosa, Albizzia procera, Acacia catechu* (Burma and local origins), *Tectona grandis, Ougeinia dalbergioides* and *Dalbergia latifolia*. The species in first group, as a rule, remain leafless much longer than those in the latter.

FIG. 12



There is, thus, no universal leafless period for the deciduous species at New Forest as is commonly associated with the temperate and alpine climates. The fairly severe winter (December to February) and the hot and dry summer (May and June) are the two important factors inducing the local flora to adopt leafless habits. Both are effective in varying degrees. The inherited traits of the different species contend against the influence of these climatic forces. This explains the diversity of phenological habits noticed here.

As already noticed, some of the species normally start producing new leaves before the old leaves are completely shed. . Out of these *Dalbergia latifolia* and *Gmelina arborea* have an average overlap of 4 and 7 days respectively, thereby indicating that their foliage is very much attenuated by the time the new foliar production commences. These two species, therefore, lie on the border line and are often classed as deciduous in habit. A scrutiny of the old records shows that all the trees under observation were actually leafless for short periods during 1931 and 1932. *Shorea robusta, Syzygium cumini, Mangifera indica* and *Pinus roxburghii* are the true evergreen species in the locality.

As in the case of leaf renewal and defoliation, differences in origin or variety give rise to marked differences in the deciduous or evergreen habits of the species. *Salmalia malabarica* of local origin is leafless for an average period of 46 days from the middle of February to the beginning of April while the same species originating from Burma seed is leafless for only 16 days during the first part of April. Similarly *Butea monosperma*, black variety, is leafless for 11 days during early April as compared with the 5 days leafless period during early May in the case of white variety of the same species. *Acacia catechu* crops of Burma and local origins exhibit only minor differences.

(*d*) *Flowering*—The available information about the average dates of beginning of flowering, maximum flowering and completion of flowering, as well as the duration of the flowering period for the various species is given in Table 7 and has been diagrammatically presented in Fig. 13.

Fig 13

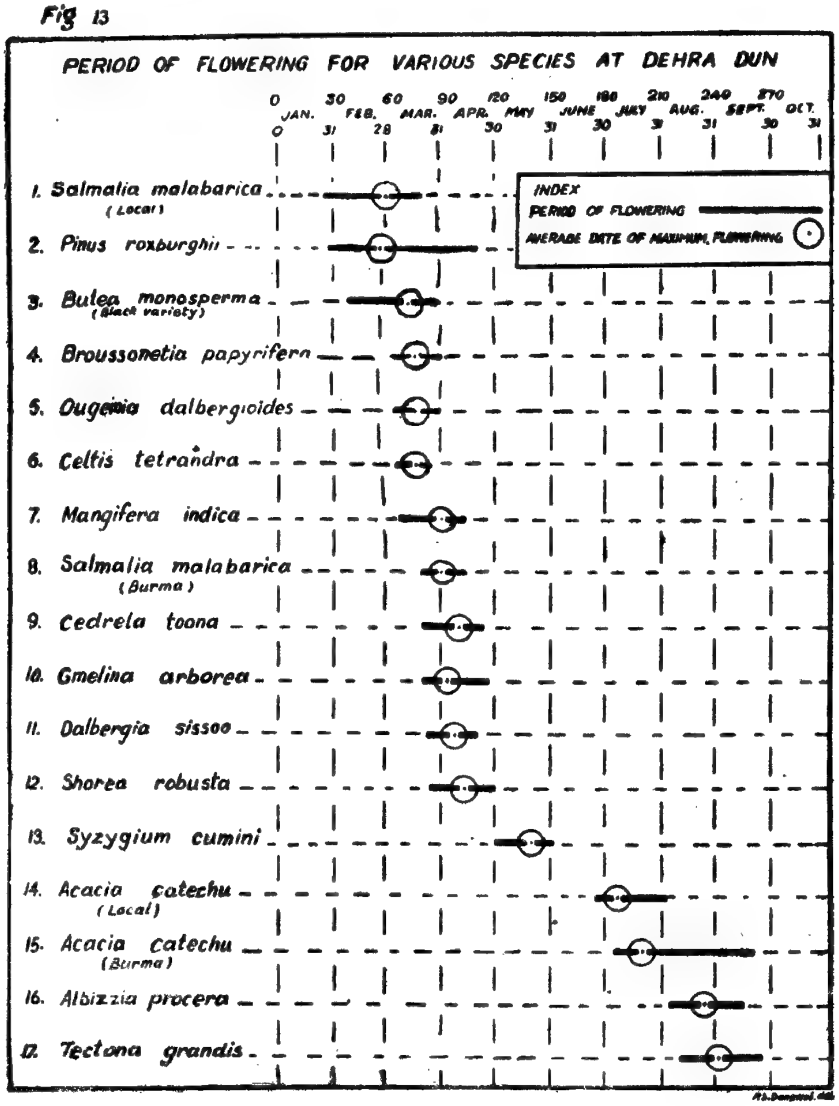


TABLE 7.—*Normal period of flowering for various tree species at New Forest*

Serial No.	Species	Average date of beginning of flowering	Average date of maximum flowering	Average of end of flowering	Average flowering period in days
1	*Acacia catechu* (Burma) . .	186	202	264	78
2	*Acacia catechu* (local)	172	188	211	31
3	*Albizzia procera*	217	236	258	41
4	*Salmalia malabarica* (Burma) . .	80	92	104	24
5	*Salmalia malabarica* (local) . .	27	61	80	53
6	*Broussonetia papyrifera*	63	77	90	27
7	*Butea monosperma* (black variety) . .	39	73	87	48
8	*Cedrela toona*	80	101	115	35
9	*Celtis tetrandra*	67	78	86	19
10	*Dalbergia sissoo*	83	99	111	28
11	*Syzygium cumini*	121	141	153	32
12	*Gmelina arborea*	81	95	118	37
13	*Mangifera indica*	68	92	108	40
14	*Ougeinia dalbergioides*	65	77	90	25
15	*Pinus roxburghii*	29	57	112	83
16	*Shorea robusta*	85	104	121	36
17	*Tectona grandis*	223	245	268	45

A few species (*Salmalia malabarica* of local origin, *Pinus roxburghii* and *Butea monosperma*, black variety) start flowering during late winter, and continue doing so till March–April. Majority of the species (*Broussonetia papyrifera, Ougeinia dalbergioides, Celtis tetrandra, Mangifera indica, Salmalia malabarica* of Burma origin, *Cedrela toona, Gmelina arborea, Dalbergia sissoo* and *Shorea robusta*) flower during March–April which is the short transition period from winter to summer and may be equated with the spring season of the temperate regions. *Syzygium cumini*, however, flowers during May which is the hottest and driest month of the year. The remaining few species (*Acacia catechu, Albizzia procera* and *Tectona grandis*) flower from the end of June to the later part of September, that is the period of heavy summer rainfall. Thus late winter and early summer (i.e., February, March and April) constitute the general flowering season for the arborescent species at New Forest, though a few may flower later during the summer or the monsoons.

It is interesting to note that in the case of the local variety of *Salmalia malabarica* although normal flowering starts during January–February, a subsidiary spurt of flowering on a much smaller scale, may sometimes be noticed during early November. As a rule these late flowers do not fructify.

The duration of the normal flowering period varies from 19 days with *Celtis tetrandra* to 83 days with *Pinus roxburghii*. Majority of the species complete this phytophase in about 3 to 5 weeks time. A few others take 6 to 8 weeks, while *Acacia catechu* of Burma origin and *Pinus roxburghii* take 11 and 12 weeks respectively.

Salmalia malabarica of local origin starts floral production 53 days before the trees of Burma origin and takes more than twice the time to complete the phase. Similarly the local *Acacia catechu* starts flowering about a fortnight in advance of *A. catechu* of Burma origin• but takes less than half the period to complete the phase. As the trees belonging to the white variety of *Butea monosperma* had not begun to flower a comparison between the two varieties of this species is not possible.

The species under consideration may be divided into the following three main groups on the basis of the comparative times of floral and foliar renewal.

(*i*) In the cases of *Salmalia malabarica* and *Butea monosperma* of both local and Burma origins and *Ougeinia dalbergioides* floral production takes place before new leaves are out. *Salmalia malabarica* flowers while it is leafless though a few old leaves might still be persisting in the beginning and odd leaflets may start appearing before the phytophase is completed. In the case of *Butea monosperma* production of flowers takes place while some of the old leaves are still on and the trees are in full bloom during the leafless period. *Ougeinia dalbergioides* also flowers while the old leaves are still present but the flowers are transformed into pods by the time the deciduous stage is reached.

(*ii*) As opposed to the above group *Cedrela toona, Dalbergia sissoo, Syzygium cumini, Acacia catechu, Albizzia procera* and *Tectona grandis* flower after foliar renewal has commenced. *Dalbergia sissoo* commences floral production when new leafing is half way through while *Cedrela toona* and *Syzygium cumini* enter on the floral phase when foliar renewal is almost over. In the case of *Acacia catechu, Albizzia procera* and *Tectona grandis* new flowers start appearing well after new leafing has been completed.

(*iii*) The remaining species belong to the intermediate group in which the two phases proceed more or less side by side. In *Gmelina arborea* and *Shorea robusta*, flowers appear about a week before the new leaves, while in the case of *Broussonetia papyrifera* and *Celtis tetrandra* the new leaves precede the flowers by an equally short period. The terminal buds in *Pinus roxburghii* start elongating about the first week of January and flowers start appearing by the end of the same month. New needles start coming out in the first week of March after which the two phases progress side by side. *Mangifera indica* starts flowering about 3 weeks before the major spurt of foliar renewal commences. The two phases progress side by side after that. It is a matter of common observation that normally branches which bear flowers and fruit do not bring forth new leaves simultaneously.

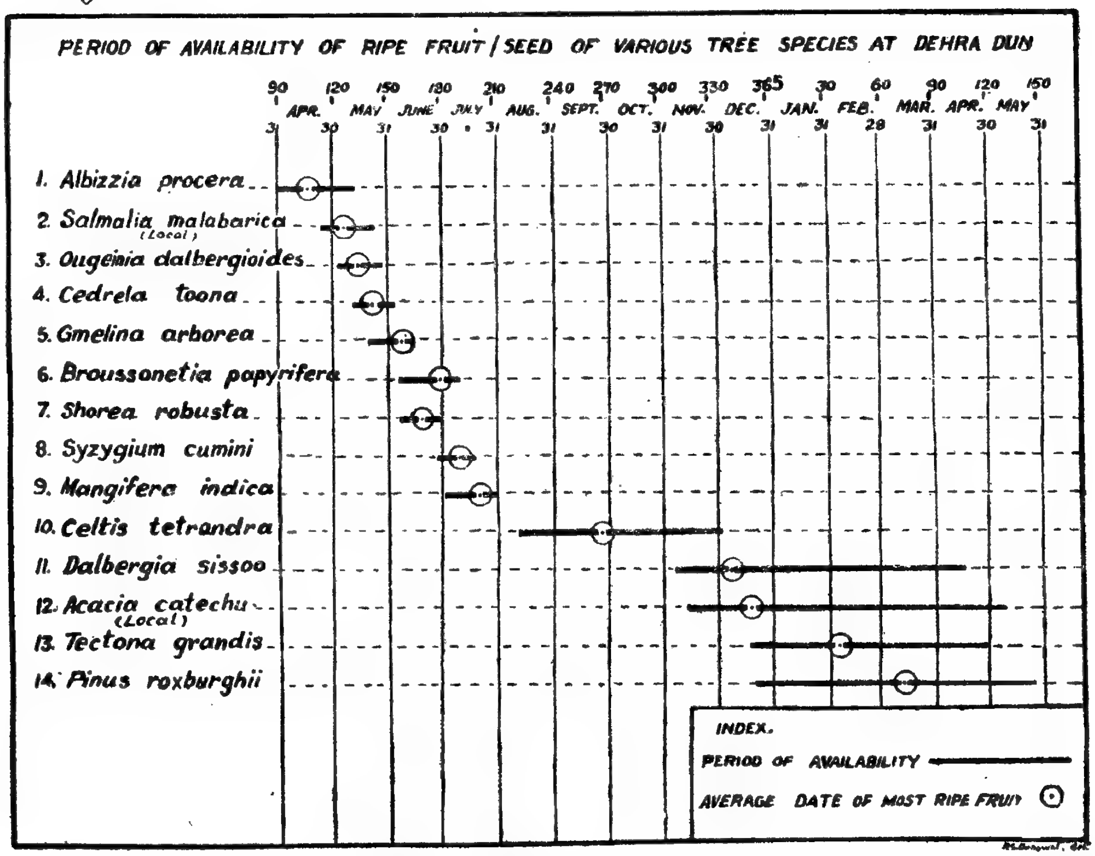
(*e*) *Availability of ripe fruit or seed*—The average dates of 'first ripe fruits', 'most fruits ripe' and 'all good seeds or fruits fallen' for the various species are given in Table 8.

TABLE 8.—*Period during which ripe fruits or seeds are available*

Serial No.	Species	Average date of first ripe fruits	Average date of most fruits ripe	Average date of all good seeds or fruits fallen
(1)	(2)	(3)	(4)	(5)
1	*Acacia catechu* (local)	317	353	129
2	*Albizzia procera*	91	108	133
3	*Salmalia malabarica* (local)	115	127	144
4	*Broussonetia papyrifera*	157	181	191
5	*Cedrela toona*	133	143	155
6	*Celtis tetrandra*	224	270	333
7	*Dalbergia sissoo*	311	342	107
8	*Syzygium cumini*	178	191	199
9	*Gmelina arborea*	141	159	165
10	*Mangifera indica*	183	202	209
11	*Ougeinia dalbergioides*	124	135	148
12	*Pinus roxburghii*	353	72	145
13	*Shorea robusta*	158	170	179
14	*Tectona grandis*	352	37	118

These data have been utilized in preparing Fig. 14 which gives, at a glance, the average dates on which maximum ripe fruits or seeds are available and the total period during which fruit or seed could be collected in each case.

Fig. 14



Out of the species for which seeding and fruiting data are now available, *Gmelina arborea*, *Broussonetia papyrifera*, *Tectona grandis* and *Pinus roxburghii* have been introduced from outside comparatively recently and may be regarded as immediate exotics to the locality. The remaining species are indigenous to the Doon Valley and these do not suggest any universal fruiting season. Some species or the other may be seen bearing fruit at any time of the year. Majority of them, however, produce ripe fruits during the pre-monsoon or early monsoon periods so that the germinating seed can take full advantage of the favourable growing conditions during the monsoons.

9. RELATION BETWEEN PHENOLOGICAL BEHAVIOURS OF TREES AND THE METEOROLOGICAL CONDITIONS

(*a*) *Factors involved*—The factors governing the phenology and the growth of plants have been studied by a large number of workers. But most of this work relates to agricultural and other cultivated plants in the temperate climates. Though our knowledge of the internal mechanisms and exact details of the various phases of life-activity of plants is still imperfect, it is generally recognized that plant behaviour is controlled by a combination of many factors which may be conveniently divided into two categories internal and external. The internal

factors or inherited traits are the outcome of the development of the species through the ages and determine the broad pattern of its phenological behaviour even when it grows in places with very dissimilar climatic conditions. The external factors modify the effect of internal forces and are responsible for the variations in the behaviour of the same species under different climatic conditions and the fluctuations observed from year to year in the same locality. Among the external factors may be listed precipitation [Champion (1), Korstain, Pearson, Schubert (cf. 1)], temperatures at different heights above ground and in the soil [Champion (1), Leven (5), Van der Veen (6), Hiley and Cunliffe (3)], frost [Leven (5), Van der Veen (6), Wareing (7)], humidity [Holttum (4), Wright (8)], soil moisture at different depths, light intensity and its duration [Van der Veen (6), Wareing (7)], reserve food materials carried over from the previous year [Burger, Kirkwood (cf. 1), Hiley and Cunliffe (3)], etc., etc.

(*b*) *Previous work done on the tropical forest species*—The work of Wright (8), Holttum (4), Champion (1) and Chowdhury (2), done on tropical forest trees, may be mentioned here briefly. Wright has recorded a number of interesting observations about the foliar periodicity of Ceylon flora and the comparative behaviour of trees in the temperate and tropical regions. He suggested that in tropical climates the presence of a dry summer is probably the most important factor in giving rise to the deciduous habit. Holttum thought that even small climatic changes have some influence on the duration of the leafless period, the susceptibility of such changes varying with different species. Champion, while investigating the seasonal fluctuations in height growth in forest tree species at Dehra Dun, found a clear relationship between height growth and weather features, particularly the mean temperature. Chowdhury, however, could not find any direct correlation between temperature, rainfall and humidity on the one hand and commencement and cessation of diameter growth on the other. He stressed the inter-dependence of these factors and the consequent difficulty of isolating the effect of individual factors.

(*c*) *Information available in the present case*—The present phenological studies offer an opportunity for determining the broad relationship between the annual variations in phenological behaviours of the different species at New Forest and the fluctuations in the main climatic factors. In addition to the detailed phenological records already referred to, temperature, rainfall and humidity data are available for New Forest for major part of the period* under consideration. Information about other external factors, e.g., soil moisture and temperature, light intensity and the reserve materials is not available. So the conclusions drawn now may at best be considered to be provisional.

(*d*) *Procedure adopted*—In order to keep the work within manageable limits the study has been restricted to 5 species, 3 climatic factors and 3 phytophases. The species selected for the purpose are *Albizzia procera*, *Cedrela toona*, *Dalbergia sissoo*, *Mangifera indica* and *Shorea robusta*. They have remained under observation for practically the same period of time†, i.e., from 1928 or 1929 to 1943. The three climatic factors taken into consideration are mean temperature, rainfall and humidity. The phytophases selected are (*a*) beginning of new leafing, (*b*) beginning of opening of flowers and (*c*) the date of first ripe fruit.

The mean temperature and relative humidity data have been presented in the form of daily mean temperature and relative humidity curves‡ for each year superimposed upon the periodic average curves (Figs. 15 to 22). The rainfall data are given in Table 9 which

* Maximum and minimum daily temperatures are available for the New Forest estate for 1931, 1933 and onwards. The data for 1928–1930 and 1932 have been obtained from the Survey of India Observatory, Dehra Dun, situated at a distance of about 3 miles from New Forest. Observations for relative humidity at 8 a.m. at New Forest are available only for the period 1931 to August 1942. From September 1942 the readings have been taken at 10 a.m. with the result that the two sets are not comparable.

† Studies on *Cedrela toona, Dalbergia sissoo* and *Mangifera indica* have been made from 1928 to 1943 and on *Albizzia procera* and *Shorea robusta* from 1929 to 1943.

‡ The daily curves are actually based on weekly averages. For this purpose each month was divided into four parts, the first three being of 7 days each and the fourth of the remaining days in the month.

Fig. 15.

DAILY MEAN TEMPERATURE CURVES

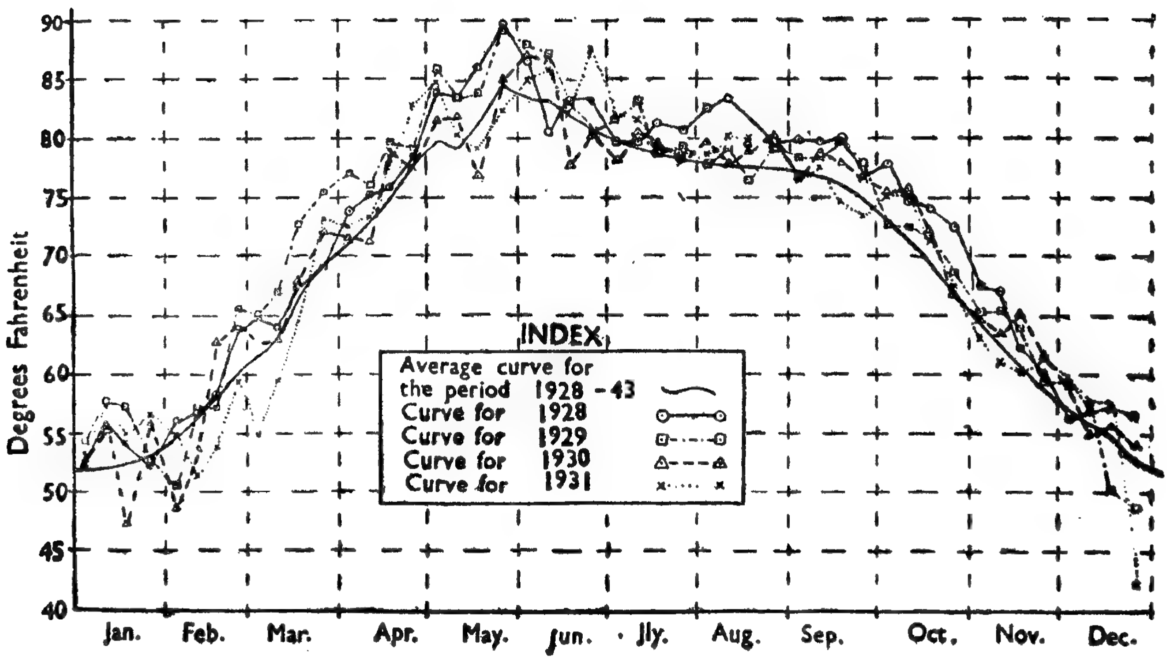


Fig 16.

DAILY MEAN TEMPERATURE CURVES

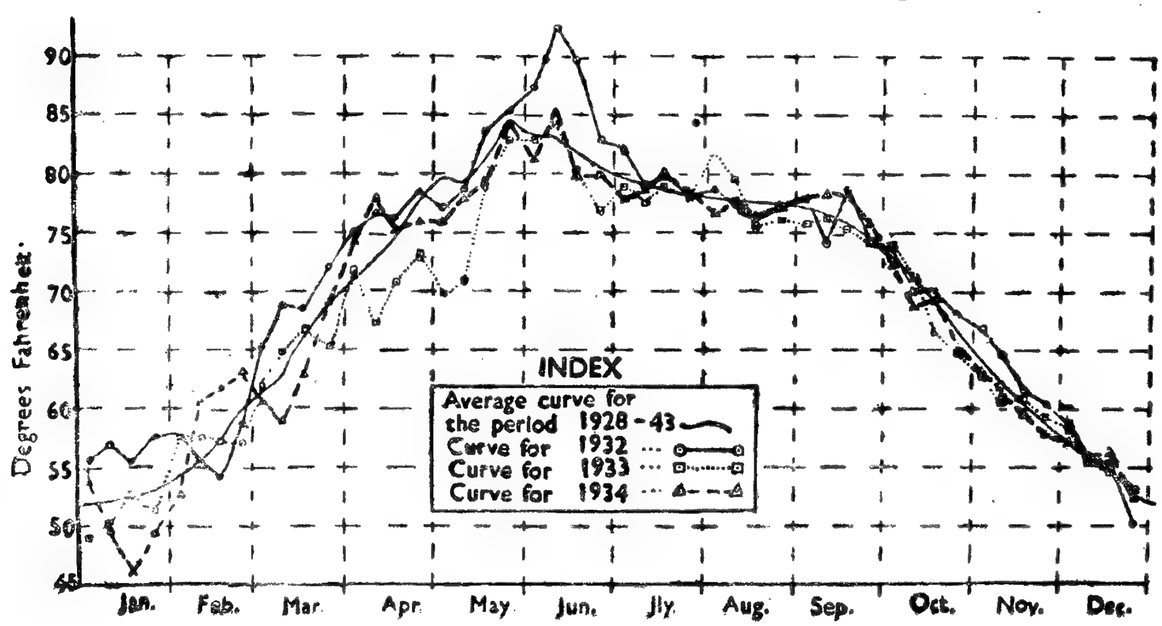


Fig. 17.

DAILY MEAN TEMPERATURE CURVES

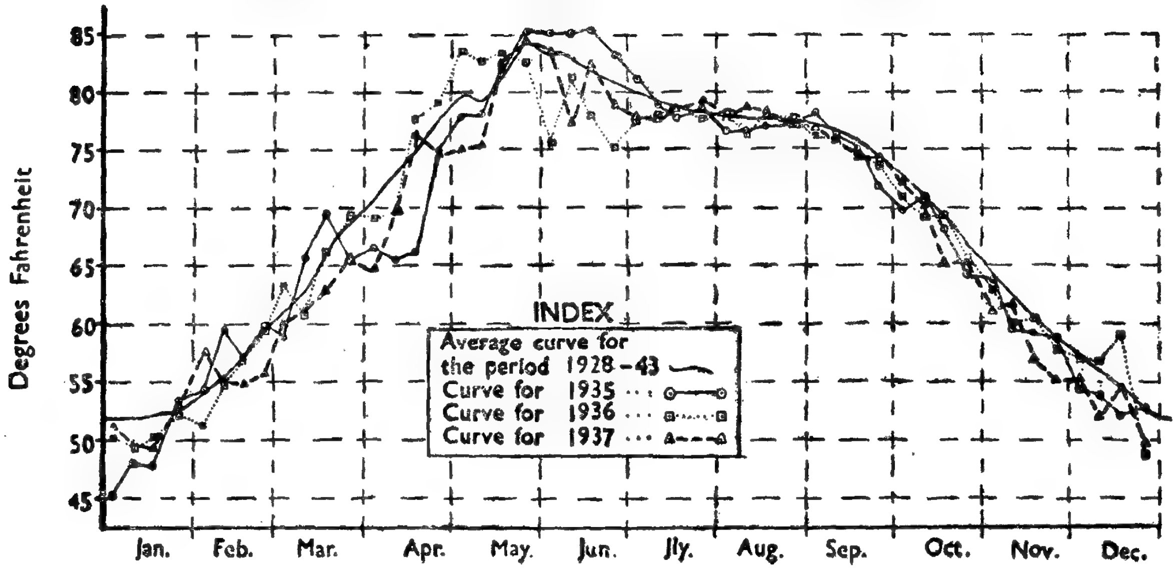


Fig. 18.

DAILY MEAN TEMPERATURE CURVES

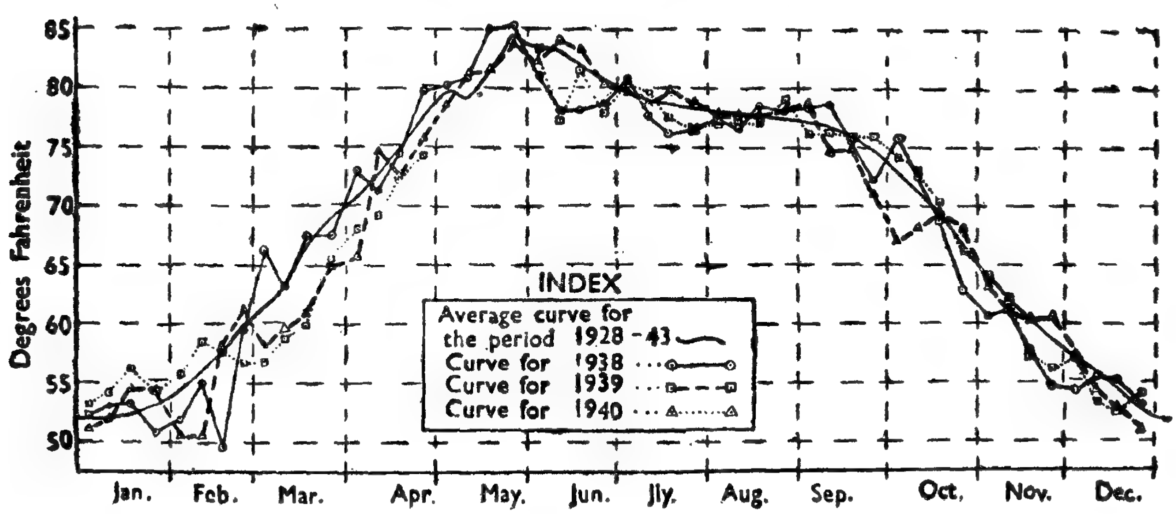


Fig. 19.

DAILY MEAN TEMPERATURE CURVES

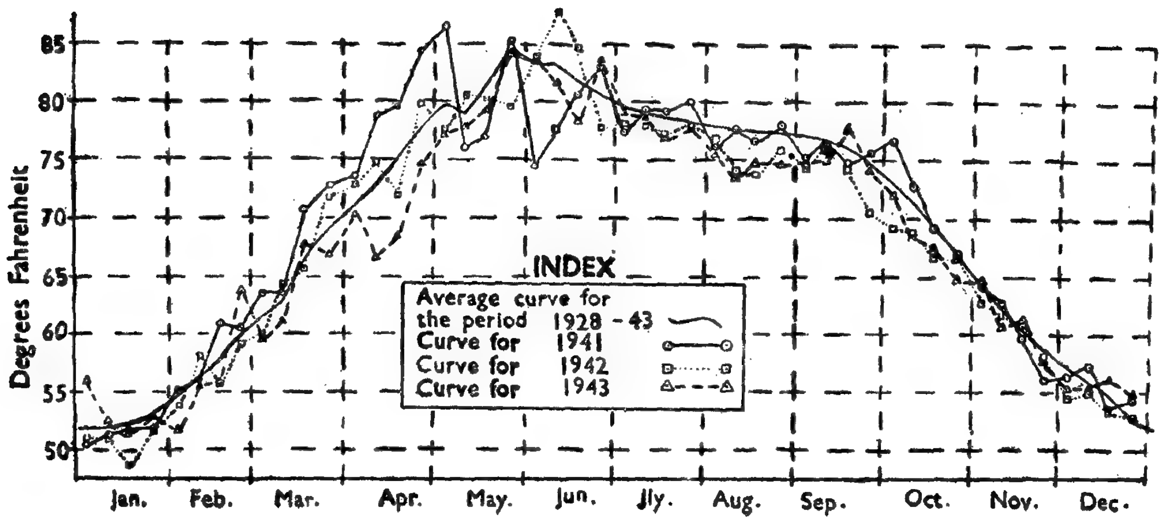


Fig. 20.

RELATIVE HUMIDITY CURVES

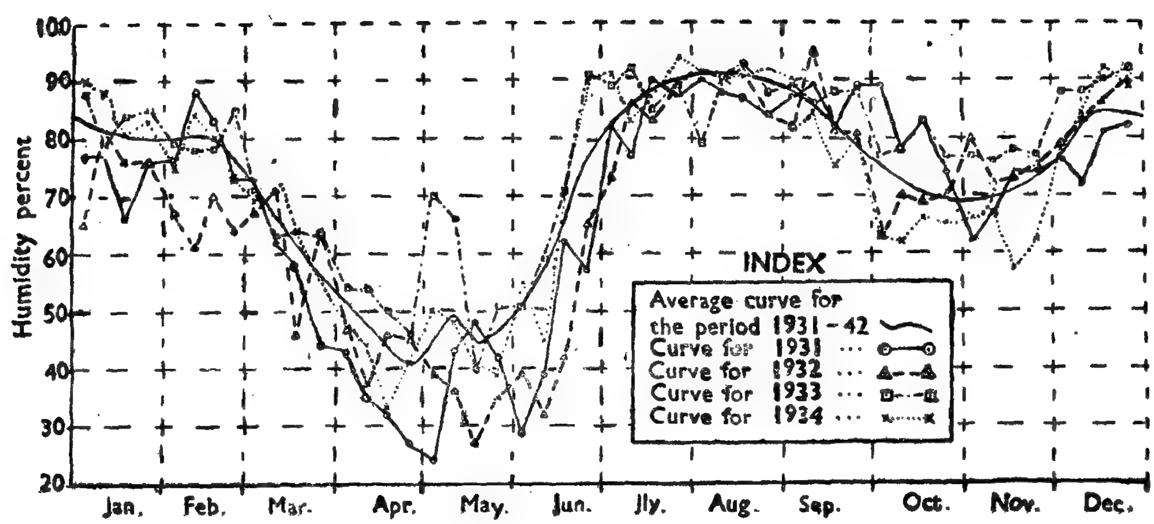


Fig. 21.

RELATIVE HUMIDITY CURVES

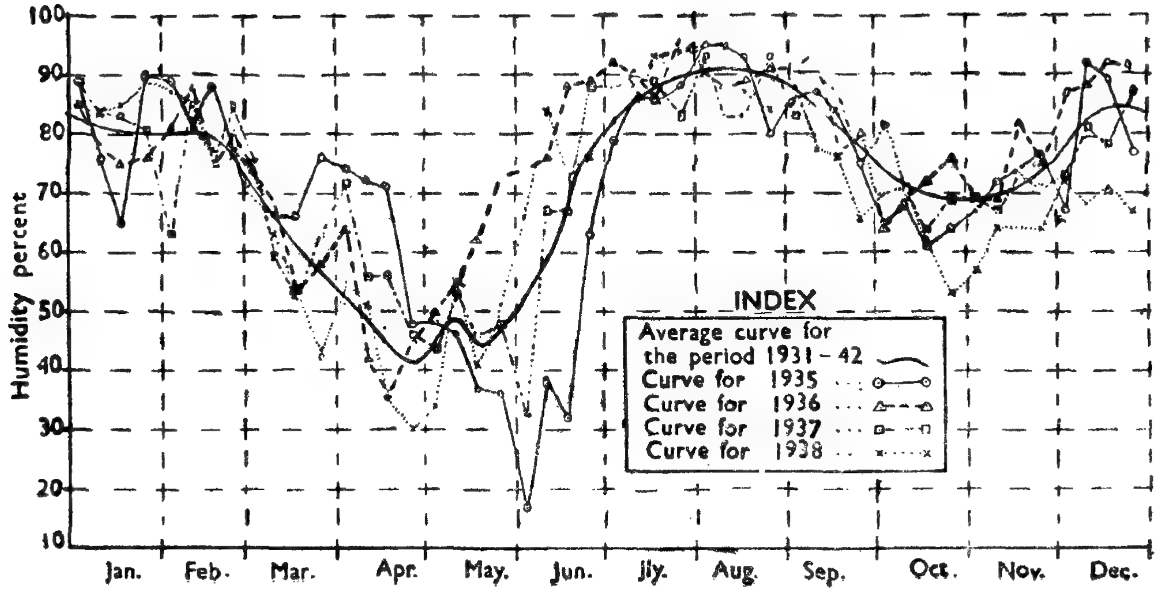
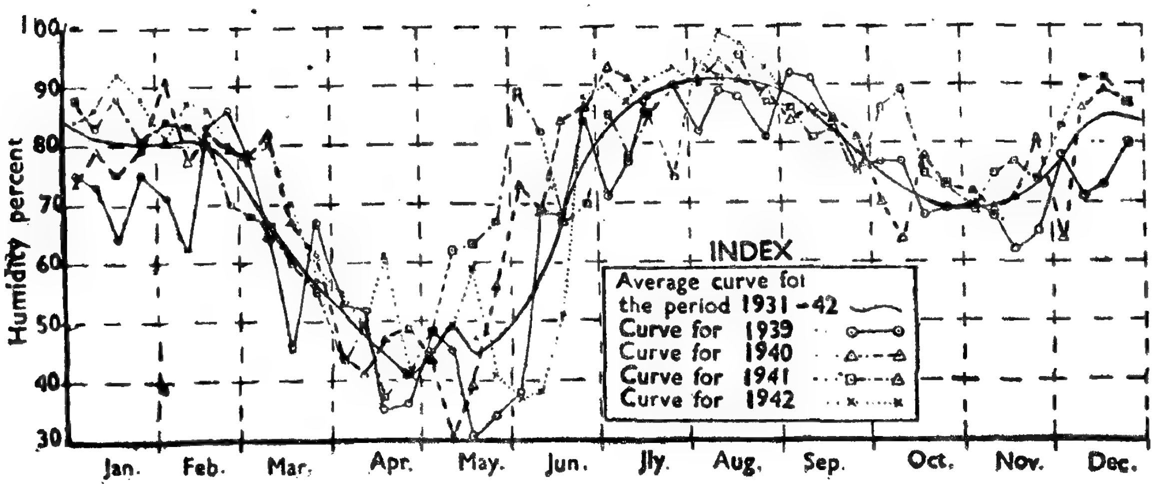


Fig. 22.

RELATIVE HUMIDITY CURVES



shows cumulative rainfall at weekly intervals for each year and average values for the whole period. As the periodic average values of temperature, rainfall and humidity for the two periods 1928–43 and 1929–43 are practically identical, those for the former period have been used in all the cases. The temperature and humidity curves and the rainfall statement thus give a clear picture of the fluctuations of the three meteorological factors from the periodic average values during the period under consideration.

The available phenological records give the dates of occurrence of the various phenomena in any particular year and the average dates for the whole period. Thus the annual variations in the date of occurrence of each phenomenon from the periodic average value can be determined. As these periodic average values reflect the adjustment of the species to the average local external factors, the fluctuations on the two sides must have a direct correlation. Hence the method of study adopted in the present case consists in comparing the two sets of fluctuations. The extreme values being likely to bring out this relationship more effectively, the two years of earliest and the two years of latest occurrence of each phenomenon have, therefore, been selected for study for each species. The conclusions thus formed are confirmed by the data for the remaining years fairly closely.

The occurrence of a phytophase on a particular date depends on the existence of suitable climatic conditions over a more or less prolonged period of time preceding the actual occurrence of the phenomenon as opposed to the conditions prevailing at the exact moment of its appearance. The length of this period is likely to vary with different phytophases and climatic factors. It has been fixed in each case on the basis of preliminary examination of the available data and the following considerations :

(*a*) Rainfall has a much more delayed influence than temperature and humidity as rain water stored in soil, continues to be utilized by the plants for considerable period after the actual precipitation.

(*b*) There are two clear drought periods at Dehra Dun – October–November and May to middle June – during which the shortage of moisture is of importance to plant life. Rainfall is very heavy during the period July to mid-September.

(*c*) The phenomena occurring in winter, spring or early summer are likely to be influenced by the total winter rainfall, as water losses during winter are comparatively small and rainfall received in the beginning of winter remains effective practically throughout winter and spring.

(*d*) Fruit is formed soon after flowering and starts developing quite rapidly in all the cases under consideration here. The date of fruit ripening is likely to be influenced by the rate of development of fruit throughout this period.

(*e*) *Detailed observations regarding different phytophases, species and climatic factors*— The observations made with respect to mean temperature, rainfall and humidity in each case are summarized in the following paragraphs. The possibilities of correlating the three phenomena with the previous years' rainfall and the occurrence of spells of exceptionally low temperatures in winter were also examined, but no positive results could be obtained.

TABLE 9.—*Progressive weekly total of rainfall at*

Month	Period	1927	1928	1929	1930	1931	1932	1933
January	1st week ..	..	1·33	..	0·07	..	..	..
	2nd week ..	..	1·33	..	1·75	..	..	..
	3rd week ..	..	1·54	0·21	3·08	..	..	..
	Remaining days ..	0·10	5·54	2·61	3·68	0·20	..	1·10
February	1st week ..	1·29	8·76	2·68	6·27	1·11	..	1·10
	2nd week ..	2·34	10·16	2·68	6·76	2·65	0·49	1·66
	3rd week ..	3·11	10·51	2·68	6·76	4·40	0·56	1·66
	Remaining days ..	4·23	10·51	2·68	6·76	4·75	0·56	2·36
March	1st week ..	4·72	11·07	3·24	6·97	6·22	0·56	2·36
	2nd week ..	5·77	11·07	3·24	7·60	6·22	0·56	2·36
	3rd week ..	5·77	11·07	3·24	7·60	6·22	0·56	3·76
	Remaining days ..	5·77	11·37	3·24	7·60	6·22	1·06	4·46
April	1st week ..	5·84	11·37	3·31	7·60	6·22	1·06	4·53
	2nd week ..	6·05	11·44	3·52	8·30	6·22	1·06	4·60
	3rd week ..	6·05	12·00	3·52	8·30	6·22	1·06	5·09
	Remaining days ..	6·05	12·00	3·61	8·66	6·22	1·69	5·36
May	1st week ..	7·03	12·00	3·61	8·66	6·22	1·69	5·50
	2nd week ..	7·03	12·28	3·61	9·43	8·04	1·69	6·83
	3rd week ..	7·03	12·28	3·75	9·85	8·11	1·69	6·83
	Remaining days ..	7·43	12·58	3·95	9·85	8·21	1·99	10·03
June	1st week ..	7·43	13·70	4·16	9·85	8·21	1·99	10·10
	2nd week ..	7·43	16·22	5·28	10·27	8·21	1·99	10·45
	3rd week ..	8·06	17·13	6·19	12·30	9·40	2·34	13·53
	Remaining days ..	8·33	18·39	7·81	15·81	9·76	6·84	28·47
July	1st week ..	11·34	23·29	11·31	24·98	12·07	7·96	36·38
	2nd week ..	17·43	28·12	11·87	28·34	14·45	13·56	45·83
	3rd week ..	27·02	39·04	18·73	28·97	21·24	18·74	47·72
	Remaining days ..	31·22	46·64	24·53	51·07	24·24	33·44	63·32
August	1st week ..	44·87	49·23	33·70	55·62	28·09	41·84	63·81
	2nd week ..	53·13	50·84	39·72	62·27	36·21	50·80	75·78
	3rd week ..	55·72	56·44	45·74	66·82	40·97	61·37	85·37
	Remaining days ..	64·12	60·14	49·94	66·92	47·17	70·37	87·47

New Forest, Dehra Dun, during the period 1927–1943

1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	Average for 1928–43
1·40	0·28	..	0·07	1·33	..	..	0·49	..	2·38	0·46
3·71	0·77	..	0·35	1·33	..	..	0·49	0·14	3·36	0·83
3·71	0·84	..	0·35	2·38	..	3·08	3·08	4·13	3·36	1·61
3·91	4·34	0·10	0·35	3·18	1·50	3·58	3·08	4·13	3·66	2·57
3·91	4·34	0·10	0·35	5·21	1·50	7·04	3·08	4·13	3·66	3·33
3·91	4·55	0·10	3·78	6·33	1·50	7·60	3·15	4·62	4·92	4·05
4·40	6·44	0·31	3·99	6·47	2·41	7·60	3·50	9·45	4·92	4·75
4·40	6·51	1·29	8·05	6·47	3·68	7·67	3·50	9·66	4·92	5·23
5·66	6·51	1·50	8·05	6·47	3·88	8·72	3·50	10·22	4·92	5·62
7·12	6·51	1·85	8·05	6·47	4·16	9·70	3·57	10·22	4·92	5·85
7·13	6·51	1·85	8·05	6·47	4·16	9·70	3·57	10·22	4·92	5·94
7·13	7·21	2·35	8·25	6·47	4·36	9·90	3·77	10·22	5·92	6·23
7·13	7·38	2·49	9·51	6·47	4·50	9·90	3·77	10·22	5·92	6·34
7·13	7·52	2·56	9·51	6·68	4·50	9·90	3·91	10·22	7·25	6·52
7·13	7·52	2·56	9·93	6·68	4·50	10·53	3·91	11·34	7·25	6·72
7·49	7·52	2·56	9·93	6·68	4·50	10·53	3·91	11·34	7·88	6·87
8·96	7·52	2·63	9·93	6·68	4·50	10·53	4·54	12·53	7·88	7·09
8·96	7·52	2·91	10·00	7·03	4·50	10·53	6·15	13·51	7·95	7·56
8·96	7·52	3·05	10·28	7·03	5·69	10·81	8·81	14·00	8·02	7·92
8·96	7·52	7·25	10·28	7·23	5·69	14·01	8·81	14·40	9·72	8·78
9·94	7·52	8·37	10·28	8·63	6·32	16·11	12·38	14·40	9·72	9·48
9·94	7·66	9·70	12·59	10·31	10·45	16·11	15·11	14·40	12·45	10·70
11·90	7·66	12·71	15·88	14·58	10·52	16·46	15·46	16·59	13·99	12·23
22·25	8·56	21·98	23·17	19·26	13·22	24·83	16·55	23·06	13·99	17·06
27·50	18·57	29·68	30·59	21·85	13·57	29·24	21·22	29·08	16·86	22·13
34·71	23·05	32·90	34·44	31·02	17·49	33·79	21·29	35·03	28·55	27·15
41·85	27·39	37·45	42·35	42·15	26·66	39·53	25·35	40·00	33·03	33·14
60·55	32·19	55·75	47·35	53·35	32·36	49·83	28·95	49·90	38·83	43·27
66·29	47·52	65·27	59·04	58·81	33·41	55·15	42·53	55·64	47·93	50·24
70·21	57·29	67·23	61·14	67·98	43·28	57·60	46·38	74·12	66·69	57·98
73·85	62·43	70·80	65·55	68·89	57·07	61·31	55·20	84·27	78·94	64·69
86·45	64·63	81·10	79·25	73·99	57·87	66·71	55·30	90·87	90·84	70·56

(contd.)

TABLE 9.—*Progressive weekly total of rainfall at*

Month	Period	1927	1928	1929	1930	1931	1932	1933
September	1st week ..	73·50	60·98	54·14	66·92	50·74	73·94	88·73
	2nd week ..	82·88	60·98	54·14	68·67	53·26	81·57	93.28
	3rd week ..	82·88	60·98	54·14	68·95	54·03	81·92	96·78
	Remaining days ..	84·68	60·98	55·22	68·95	59·07	86·15	97·77
October	1st week ..	85·31	60·98	58·02	68·95	59·28	86·15	97·77
	2nd week ..	88·25	60·98	58·02	68·95	59·77	86·15	97.91
	3rd week ..	88·25	60·98	58·02	69·16	60·33	86·15	102·39
	Remaining days ..	88·25	61·68	58·02	69·46	60·33	86·15	102·39
November	1st week ..	88·25	61·68	58·02	69·46	60·40	86·50	102·39
	2nd week ..	88·81	61·68	58·02	69·46	60·40	86·50	102·39
	3rd week ..	89·72	61·82	58·02	69·46	60·40	86·50	102·39
	Remaining days ..	89·72	62·54	58·02	69·46	60·40	86·50	102·39
December	1st week ..	89·72	63·94	58·02	69·46	60·40	86·50	102·39
	2nd week ..	89·72	63·94	59·63	69·46	60·40	86·50	102·53
	3rd week ..	90·14	63·94	63·06	69·46	60·40	86·50	102·53
	Remaining days ..	90·14	64·34	63·96	70·66	60·40	89·90	102·53

New Forest, Dehra Dun, during the period 1927–1943—(concld.)

1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	Average for 1928–43
89·67	66·17	87·82	83·03	77·91	73·27	66·71	59·01	97·73	98·26	74·69
90·37	70·02	94·05	86·12	79·59	79·15	70·00	59·15	100·46	107·22	78·01
90·37	71·35	94·63	92·34	79·66	83·84	71·19	62·02	102·63	110·09	79·69
91·27	71·35	97·74	92·34	80·02	83·84	72·36	62·02	103·08	110·54	80·79
91·27	71·35	97·74	93·11	80·02	85·17	72·36	64·05	103·08	110·54	81·24
91·27	71·35	97·74	93·11	80·02	85·17	72·36	64·75	103·08	110·54	81·32
91·27	71·35	97·74	93·11	80·02	85·17	72·50	64·75	103·08	110·54	81·66
91·27	71·35	99·04	93·91	80·02	85·17	72·50	64·75	103·08	110·54	81·85
91·27	71·53	99·04	93·91	80·02	85·17	72·50	64·75	103·08	110·54	81·90
91·27	71·91	99·04	93·91	80·02	85·17	72·50	64·75	103·08	110·54	81·92
91·27	71·91	99·04	93·98	80·09	85·17	72·50	65·59	103·08	110·54	81·99
91·27	71·91	99·04	93·98	80·09	85·17	72·50	65·59	103·08	110·54	82·03
91·27	71·91	99·04	93·98	80·09	85·17	72·50	65·59	103·08	110·54	82·12
91·27	72·54	99·25	93·98	80·09	85·17	72·78	66·01	103·08	110·54	82·38
91·90	72·54	102·33	94·12	80·09	85·17	72·92	66·01	104·34	110·54	82·87
92·10	72·54	102·63	95·12	80·09	85·17	72·92	66·01	105·34	110·54	83·39

(*i*) *Beginning of new leafing in Albizzia procera*

Average date of beginning of new leafing			= 122 (2nd May).
Date of beginning of new leafing in		1929	= 104 (14th April).
Do.	do.	1934	= 105 (15th April).
Do.	do.	1937	= 134 (14th May).
Do.	do.	1943	= 134 (14th May).
Do.	do.	1942	= 138 (18th May).

(*a*) *Mean temperatures*

1929. From the last week of February till the end of second week of April the year's curve lies above the periodic average curve by 4° to 5°F.

1934. The year's mean temperatures were 3° to 5°F. above the normal during the last three weeks of February. An equally sharp spell of cold temperatures followed during the first three weeks of March. The temperatures were practically normal during the last week of March and shot up by 3° to 5°F. during the subsequent two weeks.

1937. With the exception of the third week of April the temperatures were considerably lower than the periodic average values from the end of February to the middle of May, the difference during the last week of April and the first two weeks of May ranging between 3° to 5°F.

1943. The year's mean temperature curve shows practically the same tendency as the 1937 curve, the values remaining below the average from the last week of March to the third week of May and the differences during April ranging from 3° to 6°F.

1942. Although the phenomenon occurred 16 days after the average date, the year's mean temperature curve, as compared with the other four years discussed above, shows only minor fluctuations from the periodic average curve. The temperatures were 1° to 2°F. above normal during the last week of March and the first two weeks of April. There was a sharp fall in the third week of April when the temperatures were about 3°F. lower than the normal. This was followed by an equally sudden rise to about 2°F. above the average values in the next week. The temperatures again fell below the normal in the first week of May, i.e., about the time of the average date of occurrence of phenomenon.

(*b*) *Rainfall*

Year	Rainfall from the 1st December of the previous year till					Date of occurrence of the phenomenon
	March 31	April 7	April 14	April 30	May 14	
1929	5·04	5·11	5·32	..	..	14th April
1934	7·27	7·27	7·27	..	..	15th April
1937	11·84	13·10	13·10	13·52	13·59	14th May
1943	8·18	8·18	9·51	10·14	10·21	,,
1942	10·64	10·64	10·64	11·76	13·93	18th May
Average for the period 1928-43	7·59	7·70	7·88	8·23	8·92	2nd May

(*c*) *Humidity*

1934. Relative humidity during the last week of March and the first two weeks of April was lower than the periodic average figures.

1937. From the last week of March till the middle of May humidity was considerably higher than the periodic average values.

1942. Relative humidity was more or less normal during April and the first half of May.

1929 and *1943.* Data are not available.

Conclusions

It would thus appear that in the case of Albizzia procera high values of mean temperature during early April induce early foliar renewal while low temperatures in April and early May tend to delay it. Deficit winter rainfall and (or) low relative humidity during the first half of April probably have the same effect as high temperatures while excess rainfall and (or) high relative humidity during April act in the opposite direction.

[*To be continued*].

INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART XVIII.—CHEMICAL PULPS FOR WRITING AND PRINTING PAPERS FROM *STERCULIA ALATA* ROXB. (*LETKOK*)

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SUMMARY

Laboratory experiments on the chemical pulping of *Sterculia alata* Roxb. (*letkok*) received from the Andamans are described. The yields of the bleached pulps were not high. The bleach requirements of the pulps were high ; yet the whiteness of the bleached pulps was not quite satisfactory. The average fibre length of the wood is 1·19 mm. This investigation has shown that it is not economical to use this wood for the production of writing and printing papers. Pilot plant experiments are not planned.

INTRODUCTION

Sterculia alata Roxb. (*letkok*) is a tall handsome evergreen tree with smooth grey bark. It is an excellent avenue tree with large cordate leaves. Its wood is white and soft but harder than that of most of the other species of the genus[1]. This species occurs in the evergreen forests of Northern and Eastern Bengal and Burma, and Andaman and Cocos Islands. According to the information supplied by the Andamans Forest Department in March 1953, about 1,000 tons of this wood are available per year. This timber has not been extracted on a large scale in the Andamans for any particular use. According to an estimate of the Andamans Forest Department, the price of this wood from the Andamans will be about Rs. 205 per ton ex. Howrah Depot.

The Government of India in its general scheme of the utilization of the forest resources of the Andaman Islands suggested that *Sterculia campanulata* (*papita*) and *Sterculia alata* should be tested for their suitability for paper pulp. The work carried out in this Institute on *Sterculia campanulata* was described in previous publications[2, 3]. The results of the laboratory experiments on the chemical pulping of *Sterculia alata* are recorded in this bulletin.

RAW MATERIAL

Four logs, 8 feet long and 47–54 inches in girth, were received from the Andamans Forest Department in November 1950. The wood was almost colourless. Two of these logs were chipped and used for the experiments.

PROXIMATE CHEMICAL ANALYSIS

Chips from the wood were converted into dust in the usual way. The dust passing through 60-mesh and retained on 80-mesh was used for the proximate chemical analysis employing the TAPPI standard methods. The results of the analysis are recorded in Table I.

TABLE I

Proximate chemical analysis of Sterculia alata

		% on the oven-dry basis except moisture
1.	Moisture	10·48
2.	Ash	1·27
3.	Cold water solubility ..	6·49
4.	Hot water solubility ..	7·57
5.	1% NaOH solubility ..	18·83
6.	Ether solubility	0·45
7.	Alcohol-benzene solubility ..	1·83
8.	Pentosans	16·77
9.	Lignin	21·14
10.	Cellulose (Cross and Bevan) ..	56·21

These results suggested that this species may be tested for its suitability for chemical pulping.

FIBRE DIMENSIONS

The chips were digested by the sulphate process using 22% chemicals (NaOH : Na_2S = 2 : 1) in 63 g./litre concentration at 162°C. for 6 hours. The pulp was bleached in two stages with an intermediate treatment with 2% caustic soda (on the oven-dry weight of the pulp) at 70°C. for 1 hour. The bleached pulp was used for the determination of fibre length and diameter employing the usual procedures followed in this laboratory. Two hundred determinations were made in each case. The values of the fibre dimensions are given in Table II. The fibre length distribution is given in Table III and the fibre diameter distribution in Table IV.

TABLE II

Fibre dimensions

	Fibre length mm.	Fibre diameter mm.
Minimum ..	0·40	0·0071
Maximum ..	4·35	0·0534
Average ..	1·19	0·0286

The ratio of the average fibre length to diameter = 42 : 1.

TABLE III

Fibre length distribution

Fibre length, mm.	Number of fibres	% of fibres
0·40 to 0·50	1	0·5
0·51 to 1·00	21	10·5
1·01 to 1·50	67	33·5
1·51 to 2·00	100	50·0
2·01 to 3·00	8	4·0
3·01 to 4·00	1	0·5
4·01 to 4·50	2	1·0
TOTAL ..	200	100·0

TABLE IV

Fibre diameter distribution

Fibre diameter, mm.	Number of fibres	% of fibres
0·007 to 0·010	2	1·0
0·011 to 0·020	8	4·0
0·021 to 0·030	141	70·5
0·031 to 0·040	40	20·0
0·041 to 0·050	8	4·0
0·051 to 0·055	1	0·5
TOTAL ..	200	100·0

PRODUCTION OF PULP

The wood chips were used for the pulping experiments. Several digestions were carried out by the sulphate process using caustic soda and sodium sulphide in the ratio of 2 : 1. The quantities of chemicals for cooking were varied from 18 to 26% (on the basis of the oven-dry weight of the chips) and the temperature from 142° to 162°C. All the digestions were carried out for 6 hours ; this period included the time (about 45 minutes) required to raise the temperature of the contents of the autoclave from the room temperature to the maximum cooking temperature. The digestions were carried out in an autoclave of 3-litre capacity using 200 g. chips. After the digestion, the pulp was washed and bleached in two stages. In the first stage, about 75% of the total bleach was used. After the first stage of bleaching, the partially bleached pulp was treated with 2% caustic soda (on the basis of the oven-dry pulp) at 70°C. for 1 hour. The pulp could not be bleached to a good white shade even though excess of bleaching powder solution was used.

The bleached pulp was beaten in the Lampen Mill and standard sheets were made on the sheet making machine recommended by the British Paper and Board Makers' Association.

After drying in air using plates and rings, the standard sheets were conditioned at 65% R.H. and 70°F. and tested for their strength properties. Their brightness was determined using Photoelectric Reflection Meter Model 610.

The digestion conditions, pulp yields, bleach consumption, strength properties and brightness of standard pulp sheets are recorded in Table V.

DISCUSSION

From the results recorded in Table V it is clear that the bleach consumption decreased when the temperature of the cooking was increased from 142° to 162°C. The bleach consumption was, however, high compared to bamboo or other woods of the broad leaved species tested so far in this laboratory. The bleached pulps were not quite white. When a larger quantity of bleaching powder was used for bleaching, it was found that the excess of the bleaching agent could not improve the whiteness of the pulp even though it was left in contact with the pulp for a longer time.

The yields of the bleached pulps decreased generally when the temperature of the cooking was increased from 142° to 162°C. Although well-cooked pulps were obtained when 24–26% chemicals were used for the cooking, the yields of the bleached pulps were low compared to other woods of the broad leaved species examined so far in this laboratory. Generally, the strength properties of the pulps also fall down when the temperature of the cooking is raised from 142° to 162°C.

In view of what is said above, it is not proposed to carry out pilot plant trials on the production of writing and printing papers from this species.

CONCLUSIONS

1. Yields of bleached pulps from *Sterculia alata* are low compared to woods of the broad leaved species examined so far in this laboratory.

2. The bleach consumption is high. Even with excess of bleaching powder, the pulps from this species could not be bleached to satisfactory whiteness.

3. The results of this investigation indicate that it is not economical to use this wood for the production of writing and printing papers.

Thanks are given to the Chief Forest Officer, Andamans, for the supply of the wood for this investigation.

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TABLE V.—*Sulphate digestions of the wood of Sterculia*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals* (NaOH : Na_2S=2 : 1)	Concentration of chemicals	Digestion temperature	Digestion period	Consumption of chemicals*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder containing 35% available chlorine*	Bleached pulp yield*
	%	g./litre	°C.	hours	%	%	%	%
1	18	51·4	142	6	15·9	48·0	23·4	41·8
2	18	51·4	153	6	16·9	46·8	16·9	39·9
3	18	51·4	162	6	16·8	48·3	15·8	35·7
4	20	57·2	142	6	17·4	48·7	17·4	43·1
5	20	57·2	153	6	19·5	47·4	16·0	38·8
6	20	57·2	162	6	18·5	48·2	13·5	39·6
7	22	63·0	142	6	18·5	50·8	12·9	41·2
8	22	63·0	153	6	20·2	45·3	11·6	40·6
9	22	63·0	162	6	20·6	46·2	11·4	39·4
10	24	68·6	142	6	19·2	46·6	12·3	37·8
11	24	68·6	153	6	22·4	44·4	12·7	36·4
12	24	68·6	162	6	21·6	44·0	10·5	36·6
13	26	74·3	142	6	20·5	45·6	13·9	36·2
14	26	74·3	153	6	22·8	44·3	12·5	34·8
15	26	74·3	162	6	22·5	43·1	11·9	33·8

* The % is expressed on the basis of the raw material (oven-dry).

alata and strength properties of Standard pulp sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 70°F.

10	11	12	13	14	15	16	17	18
Freeness of pulp	Basis weight	Breaking length (Schopper)	Stretch	Tear factor (Marx-Elmendorf)	Burst factor	Folding endurance (Schopper)	Brightness	REMARKS
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds		
305	60·0	10120	3·7	76·7	65·5	700	59	Under-cooked pulp containing shives was obtained.
310	62·3	9040	3·1	55·6	78·3	510	61	The pulp was not free from shives.
366	61·5	9430	4·5	86·4	64·4	930	61	No shives were present.
274	59·5	10640	3·7	102·9	71·9	1450	58	Shives were present in the pulp.
298	62·7	9208	3·3	85·4	63·8	580	59	Like bleached pulps in Serial Nos. 1–4, the bleached pulp was not quite white.
310	57·0	8570	3·8	96·0	54·5	420	59	Shives were not present. The bleached pulp was not quite white.
313	59·7	10130	4·0	135·6	70·4	1550	55	Shives were present. The bleached pulp was not quite white.
330	58·3	8900	3·9	128·1	55·4	690	57	Do.
326	60·0	8470	3·3	90·4	50·0	430	59	Well-cooked pulp. The bleached pulp was not quite white.
327	59·4	8780	3·7	140·3	55·0	970	55	The pulp was free from shives but the bleached pulp was not quite white.
303	61·0	8000	4·1	89·8	49·1	340	60	Well-cooked pulp was obtained. The bleached pulp was not quite white.
305	59·7	7360	3·3	90·4	47·5	310	62	Do.
326	60·0	9280	4·0	78·6	51·4	870	62	Do.
300	61·4	7330	3·5	74·3	64·2	170	61	Do.
297	60·6	7420	4·0	85·0	45·0	220	59	Do.

ARTIFICIAL REGENERATION WITH SELECTION METHODS OF WORKING "COMPENSATORY DIFFUSE PLANTATIONS"

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SUMMARY

In preference to large scale concentrated plantations, compensatory diffuse plantations are advocated, since they do not involve firstly inclusion of any unsuitable sites within the plantations and secondly any sacrifice of established tree growth. This method of planting would in stages regenerate the irregular forests deficient in natural regeneration, being perhaps one of the simplest and cheapest methods of regenerating a selection felled forest and one that fairly resembles nature's own way of rehabilitating it.

INTRODUCTION

1. Compensatory diffuse plantations are patch plantations fairly well scattered over the area of the coupe to the extent necessary to compensate the deficiency in natural regeneration. Obviously, where natural regeneration is sufficient there is no need for such plantations. If some natural regeneration is obtained the area of diffuse plantations could be reduced in proportion to the degree and extent of regeneration. The advantages of these plantations over the concentrated plantations are discussed in later paragraphs.

2. Situation, Locality and General description of forest: This note is based on the study of the teak forests of North Kanara District of the Bombay State. These forests are situated mostly in the valleys through which the many rivers flow from the heights of the Western Ghats into the Arabian Sea. The altitudes vary from 500 to 2,000 feet. The rainfall is anything between 60 to 150 inches. The principal rocks are schist, granite and gneiss. The country is mountainous with slopes of varying steepness.

The forests are generally of Moist Deciduous type corresponding to 3(*a*) C1 of Champion's classification which imperceptibly merges into the Western Tropical Evergreen type corresponding to $1aC_3I$ at higher elevation, where rainfall is more and biotic influences are not felt. The species of commercial importance are teak (*Tectona grandis*), *shissum* (*Dalbergia latifolia*), *matti* (*Terminalia tomentosa*), *nana* (*Lagerstroemia lanceolata*), *kindal* (*Terminalia paniculata*), *jamba* (*Xylia xylocarpa*), *heddi* (*Adina cordifolia*), *dhaman* (*Grewia tiliaefolia*), and etc. These species occur all mixed in various proportions according to the varying factors of the locality and micro-climatic influences but the percentage of teak seldom goes more than 20%. The percentage and the quality of teak is the main criterion which governs the commercial value of these forests, quite apart from their importance as the watershed area of the river system. The common undergrowth is bamboo. There is, in addition to bamboos, a fair amount of rank growth of weeds and herbs. Much difficulty is experienced in getting established natural regeneration of teak as most of it gets killed for want of overhead light. *Jamba* in some areas regenerate profusely. Other economically important species regenerate to some extent but not sufficiently. There is always the danger of bamboos monopolizing the gaps created in course of fellings.

3. Object of Management: The production of timber of large dimensions mostly of teak (*Tectona grandis*) and other valuable species such as *shissum* (*Dalbergia latifolia*), *honne* (*Pterocarpus marsupium*), *matti* (*Terminalia tomentosa*), *nana* (*Lagerstroemia lanceolata*).

4. Silvicultural System practiced hitherto : The forests are generally worked under Selection Method. Most common method of working is the Selection-cum-Improvement fellings. It has been found to be very difficult, though not impossible, to successfully apply the High Forest Systems, that are in vogue elsewhere, to the mixed forests of these areas. In spite of the paucity of the natural regeneration and the yield of principal species like teak falling down from felling cycle to felling cycle, the method of Selection-cum-Improvement fellings has been practiced in most of the places for want of a better method. The high yield realized in the past is partly attributed to the over-stocking of mature trees at the commencement of the period of systematic management. Absence of adequate natural regeneration has been a problem for the forest man since the earlier days of the systematic working.

DIFFUSE PLANTATIONS *vs.* CONCENTRATED PLANTATIONS

5. When it was recognized that adequate regeneration, an essential condition in Forest management, is not attained naturally, the forester had, therefore, to think of introducing it artificially. The extent of artificial regeneration attempted was to replace the mature stock lost in fellings and also to improve the growing stock. In this way most of the plantations were raised on suitable sites either within the coupe or elsewhere. Much area in compact block was thus clear-felled and planted. But the question arises : are we justified in depleting a major portion of the area of valuable species and changing its character and relying purely on this kind of compensatory plantations ? The area worked is too large in comparison with what is planted in some little portion of the coupe. The gaps, like the pepper pot holes created in the canopy in the area of the coupe other than the plantations, are left uncared for, only to be invaded by bamboos and weeds.

6. Another important aspect lost sight of in creating concentrated plantations was some amount of sacrifice of established young crop of important species, involved in the clear-felling operation. It was not always possible to exclude such areas as covered by young healthy crop in creating concentrated plantations since the idea was to plant in compact blocks for reasons of better supervision and accessibility. Most of the accessible area has been clear-felled and planted by now. The regeneration operations have at present to be confined to slopes. Large scale clear-felling and burning to plant the areas to achieve the adequate regeneration is detrimental because of the excessive erosion due to heavy rains and steep gradients. Hence concentrated plantations are not desired as they deplete the established advance growth by clear-felling, which would otherwise form the part of the future crop, and they cause in many cases severe erosion.

7. Clear-felling, burning and planting operations require much capital and supervision. To add to these two, labour is also a problem. In these areas, only imported labour has to be depended upon. As such, there are ever so many difficulties in procuring labour enough to do all the operations. Supervision is quite necessary to carefully execute all programmes of cultural operations. Cleanings, cultural operations and thinnings require skilled foresters. The high initial cost is justifiable only if these plantations are carefully attended to by carrying out cleanings, cultural operations and thinnings whenever they are required. Thus heavy capital expenditure skilled supervision, scarcity of labour go to make up the task of concentrated plantations a very difficult one, besides being undesirable for reasons of erosion and sacrifice of the young established crop.

8. In a natural forest it is observed that teak occurs in groups only. Similarly in a large scale old plantations, plants are observed to be established in patches, even though entire area was originally uniformly planted. Hence it is necessary to note that teak has specific needs from site point of view for its establishment. These needs cannot ordinarily be met with uniformly on large stretch of lands since, topography, rock, soil, drainage, etc.,

change considerably from place to place. This makes it difficult to select the sites suited to teak. Nature indicates it better ; where teak originally grew well, there, it necessarily follows teak can artificially be grown. As such in selecting sites it should be borne in mind that the sites bearing healthy teak are given the priority. It is, as well, found that certain sites, devoid of teak but bearing healthy growth of its associates, are found on trial unsuited for the cultivation of teak. Hence it can be said, with fair amount of certainty that success of the plantations often depends on the suitability of the sites. The sites in these forests suited to teak can be obtained only in patches, and not in large concentrated areas. It follows that the gaps caused by removal of selection teak trees are ideal sites for growing teak.

9. From the discussions made under paragraphs 5 to 8, it is believed that gap regeneration should be preferred to concentrated plantations in these areas. The serious objections to gap regeneration are (1) The gaps are small and are easily lost sight, (2) They are distributed far and wide so that supervision of cultural operations is difficult, (3) The gaps are soon overtopped by the surrounding and the regeneration killed out right in course of time[1].

10. The method detailed below under the name "Compensatory diffuse plantations" is the one which overcomes all the objections raised under paragraph 9 and which meets the requirements of the selection felled areas for the purposes of regeneration and maintenance of the natural proportion of the composition and the Character of the crop.

When any annual area is felled under Selection-cum-Improvement fellings there will be gaps created in the canopy. These gaps should be widened to the possible extent taking care as far as possible not to disturb the existing groups of established young advance growth. In widening the gaps the areas covered by useless growth, bamboos, and weeds must be first taken up. In North Kanara the density of these moist deciduous forest is low varying between 0·2 to 0·5. It is not difficult to widen the gaps by removing useless growth. The regeneration should be made up by planting these widened gaps. The plantations thus created will be all scattered over the entire area of the coupe, since the fellings of the selection trees are scattered. The term gap regeneration is avoided because gaps are widened to certain extent on silvicultural grounds. The term patch regeneration is also not appropriate to these plantations since it does not convey the meaning that they are all scattered over the entire area. To indicate that the plantations are carried out in order to compensate the removal in fellings of important species the adjective compensatory is necessary. The word diffuse would signify that the compensatory plantations are done all over the area. Hence compensatory diffuse plantations would mean that the regeneration is achieved by scattered patch plantations carried within the coupe after execution of fellings of the selection type.

11. All patches suited to teak shall be planted with teak. Other patches shall be covered by species suited to the sites like *sawar* (*Bombax malabaricum*) cultivation of which is of economic importance. By this method the natural character of the forest can be better retained in the way that is most desired. Side by side, the value of the forests would be increased with increased amount of more valuable species within the coupe.

12. The success of this method depends on the size of these individual diffuse plantations, since teak as well other species such as *sawar* (*Bombax malabaricum*) suffer very badly both by overhead shade and drip. From the experience it can be safely stated that the size of the teak plantations could be anything more than a square chain. In addition, till such time as the plants could well establish the drip should be minimized by lopping the trees surrounding the patches. On ideally suited sites with overhead opening, the stumps will easily establish satisfactorily. It is necessary that all the felling debris, bamboos, undergrowths like *karvi* (*Strobilanthus* species) are heaped and burnt carefully. In moist deciduous forests, the character of the undergrowth generally being evergreen, the fire often does not

spread out of the clear-felled area. The burning has to be so very skilfully done as to kill the bamboo rhizomes and other undergrowths. The surrounding bamboo is also cut and added to the burning material. There is evidently another advantage of these plantations that the felling refuse is usefully burnt to prepare the sites, which would have been otherwise a source of injuries by way of fungi, insects and fire in the hot weather. In this fashion teak and *sawar* (*Bombax malabaricum*) depending on the suitability of sites can be planted since the technique of both is fairly well-understood. Other species can be tried on an experimental scale. These spots of plantations can be roughly indicated on 4-inch maps with the help of topographical features by crimson 'T's. These Ts can be maintained and spotted out in the coupe. Hence there is no danger of these sites being lost site of.

13. The question of weedings, cleanings, cultural operations, thinnings, deserves much consideration. There is no doubt that during the first two years of formation, weedings and cleanings, are essential. These plantations have to be attended to for the first two years, side by side, it would be really true silviculture if the area other than the plantations are gone over in order to free the natural regeneration and the coppice to whatever extent it has added, and to cut climbers, etc. This is not usually done for reasons of economy. It is false economy to let these areas go unattended. When attending to all the diffuse plantations forest man has to cover the entire area of the coupe, and this offers him an opportunity of attending the other areas also.

14. It is an admitted fact that the period of felling cycle usually 30 years so far practiced is too long. With such a long interval, each unit of area of the forests receives attention only once in 30 years. At this rate the general improvement of the forests cannot be achieved. It can easily be seen that larger the felling cycle smaller will be the area to be worked in any one year. To make the fellings remunerative it is observed that more often than otherwise, the fellings become heavy amounting to revenue fellings. This kind of heavy selective fellings, cutting out of certain kinds of trees only, in the absence of adequate natural regeneration, would alter the ecological structure. A closer inspection of the forests worked in the past readily indicates this development. Hence the period of the felling cycle must be brought down to the level of 10 to 15 years, so that the intensity of the fellings would be minimized, besides, the attention that could be paid to the entire coupe would be more frequent than that at present. By scattered fellings, as a result of the reduction in the period of the felling cycle, the working may become uneconomic. This situation cannot be helped, since, in the larger interests of maintaining the productivity of these forests in perpetuity, chief aim in the forest management, the consideration of economy has to be subordinated. Thus for reasons explained above if the felling cycle is brought down to 10 to 15 years, the thinnings in the diffuse plantations can be combined with the main fellings with added advantage of increasing the yield by the amount of thinning material. The spacing in the plantations can be 9×9 feet with 10 to 15 years as felling cycle so that 1st thinnings can very well be done along with the main fellings. In true selection system there is a provision for thinnings amongst the younger age trees. Therefore, at the time of main fellings thinnings may be done amongst the groups of poles in the area other than plantations, and with a fair amount of accuracy in the diffuse plantations. This way, the entire coupe will be attended for general improvement. If for any reasons the period of the felling cycle is not brought down to the desired limit, programme of thinnings as subsidiary operations should be given ; so that the second thinnings in the diffuse plantations can be combined with the main fellings during the succeeding felling cycle. It is felt that the working plans should be so designed as to take all these into consideration. This being so, the first step necessary is to revise our ideas on which our Working Plans are framed ; to base our treatment on the silvicultural requirements of the species dealt with, not to calculate the yield and proceed to exploit it without regard to

regeneration and the attainment of normality ; but fix areas for regeneration, to proceed to regenerate them, and *pari passu* to exploit the yield as calculated on the basis of these regeneration operations together with such surplus material as may be furnished from subsidiary fellings in areas not under regeneration[2].

15. A beginning has been made in blocks XXIV and XXV of Kanara Western Division in creating diffuse plantations, though not strictly in the sense of compensatory diffuse plantations. Teak stumps were planted in 1950 in patches, where permanent gaps had been formed. Gaps were widened. A fair amount of success has been achieved. There is no reason why compensatory diffuse plantations should not be successful if they are carefully done as outlined in the above paragraphs.

Compensatory Diffuse Plantation of teak (*Tectona grandis*) in Moist Deciduous Forest in Kanara Northern Division (Sambrani Range).

Photo : K. G. Holdipur.

CONCLUSIONS

16. The essence of this method of regeneration is—

(1) The regeneration of the species without any drastic operations like large scale clear-felling and burning.

(2) Retention of the advance growth of important species and carefully attending it, so as to utilize the same as part of the future crop.

(3) Maintenance of the character and composition of the crop as silviculturally desired.

(4) General improvement of the forest by augmenting the proportion of the economic species within the crop.

(5) Fair amount of distribution of the age-classes over the area of the entire forest under treatment.

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THE PHENOMENON OF TWISTED TREES

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The phenomenon of twisted trees appears to have aroused the curiosity of men from earliest times and stimulated speculation as to the underlying causes. Many observers were quick to notice that a spiral twist, whether left-handed or right-handed, was observable throughout nature, both in the plant and animal kingdom, and even in the inorganic world, namely the crystal shapes in minerals. This universality of the phenomenon sounded a warning that twist in trees was not to be explained away by any particular factors of physiology or environment. One had to be vaguely content with conceding that twisting was inherent in many organisms, and in minerals, perhaps rooted in molecular phenomena.

In the inorganic world, besides the crystals which show right-handed or left-handed growth, in the Liesegang effect where precipitation of salts in gels takes place in rings, occasionally instead of concentric rings a fine spiral is produced, thus indicating that this is a physico-chemical phenomenon (Seifriz, 1933 a).

The outstanding example of twist in the animal kingdom is the dextral and sinistral twists occurring in Molluscan shells. Man himself has been regarded as a spirally twisted organism, the gall duct being conspicuously twisted to the right. The cardiac loop, viscera, the colon, trachea and oesophagus show dextral rotation. The spiral trend is seen in muscle fibres, in fibrils making up layers of wood-cell walls, and in the chromosomes (Seifriz, 1933 b). A blind-folded man walks in a right spiral.

Organs of plants such as tendrils and even microscopic structures such as cotton fibres show both dextral and sinistral twist. It would seem that the spiral development among organisms is the expression of a wide-spread tendency which is protoplasmic in origin (Seifriz, 1933 a, b). The curling and twisting of wood fibres, silkworm and spider's web, the spiral growth of bacterial colonies, all point to fundamentals underlying the evolution of organized matter (Copisarow, 1933). Copisarow (1932) reveals his bias for physico-chemical phenomena in explaining twist.

PREVIOUS LITERATURE ON TWIST

Twist in plants has been noted by naturalists from early times such as by De Candolle in 1827, Von Truchess 1840, Wichura 1852, Braun 1854, De Bary 1877, Hartig 1888, Schlich 1896, and Nisbet 1905 (see Champion, 1925). Perhaps the earliest to notice twist in India was Hearle in 1895 at Ranikhet (see Smythies, 1915). Smythies published his note on twisted fibre in *chir* pine and discussed the locations and soil where it occurred and the probable environmental causes. He raised seedlings from seed of intensely twisted trees but got straight-grained progeny. Canning (1915) followed up within a month in a paper on the same subject and noted some detailed characteristics of the occurrence. In one area he found that where mother trees were right-hand twisted the seedlings came up with left-hand twists. Troup's silvicultural study (1916) of *chir* pine incorporates remarks mostly after Canning and Smythies' reports. In his later work (1921) he again discussed the subject, and seeing from the evidence that seed of twisted trees gave both twisted and straight-grained progeny admits that the question of heredity has not been satisfactorily solved.

Champion (1925, 1930) investigated the phenomenon over 14 years and conducted some experiments with seedlings. He also discussed the effect of various factors such as internal

tensions of growth, the action of wind, and the spiral tissue elements. He brought out the following conclusions :—1. Varying degrees of twist are common in many species. 2. There are fluctuating variations in the directions of the fibre. 3. Twist is capable of being transmitted from one generation to the next. 4. Twist as an acquired character is untenable. 5. Twist may be a mutant character, surviving because of removal of straighter trees by man. 6. Forest management can eliminate twisted trees by thinning and seed-selection.

During the 1930's a series of short papers on the subject of twist in trees appeared in American periodicals, particularly "Science". Wentwork (1931) observed twist in the coniferous trees of Montana, which includes pines and spruces. He noted the predominant right-handed twist (384), although there were a few (16) of the opposite kind, and posed the question whether left-handed twist occurred in the southern temperate zone. This implied that the earth's rotation had an influence on the twist in the northern and southern hemispheres as in the case of the Trade Winds. Butler (1931) had obtained information to the effect that in southern hemisphere the twist in the case of apple trees is dominantly to the left. He thought that twist was not influenced by soil, wind or weather, but probably was a form of tropism. Jones (1931) noticed that in Massachusetts maples showed a pronounced right-handed twist, and elms only a left-handed twist. Thus the concept of the effect of rotation of the earth on twist appears doubtful.

Edwards (1931) cites an interesting early utilization of twist in trees. In 18th century and early 19th century in America twisted timber was employed in making the mould-board portion of the "Wooden Plow". Hardwood trees with close left-hand twist were greatly prized for the purpose. One Nathaniel Edwards, b. June 21, 1752, Haverhill, Mass. and d. June 14, 1828, Casco, Maine, known as "Plowmaker Nat" is recorded as having specialized in this use.

Jacot (1931) observed that in North China the twist in *Thuja orientalis* was to left and in *T. occidentalis* to right. Of 438 trees 272 had twist to left, 157 not twisted, 6 had only the lowest 2 feet twisted, one twisted in different directions every 3 or 4 feet and 2 twisted to right. No correlation was found with exposure, inclination of tree, or any obvious environmental factors.

Cahn (1931) observed in Ontario twist in *Thuja occidentalis, Pinus strobus, P. resinosa* and *P. divaricata.* It was not seen in 'hardwoods'. In cedars, out of 312 trees 291 were twisted, 187 of which were right-handed. Twist occurred in trees exposed to gales on rocky cliffs.

Koehler (1931) in Colorado reported that out of 396 alpine fir trees 85% had right-handed and 14% left-handed twist leaving only 1% straight-grained. Of 26 pines 14 had right-handed and 4 left-handed twist. In a lumber mill at Tacoma he found that of 463 Douglas fir logs, 94 were left-handed and 8 right-handed. Koehler also refers to Champion's find that seedlings of straight-grained trees showed fewer with twist.

Herrick (1932) observed twisted trees in Louisiana. He found that out of 1527 trees 364 (23%) were straight-grained, 811 (53%) were right-handed, 352 (24%) left-hand twisted. Out of 57 roots of trees he found 31 (55%) were twisted to right both in taproot and side roots. Seven (12%) showed left-hand twisting, 19 (33%) straight. He further noted that the degree of twisting was considerably more at the surface than towards the interior, indicating that trees get more twisted at the surface as they grow older.

Knorr (1932), who also enumerated twisted trees found in Jackpine in California that of 486 trees 56% were twisted left-hand and 44% right-hand. The bark, it should be remembered, does not always twist as does the wood, and so one should be wary about estimating twist from exterior indication alone.

As to the causes of twist, it is now generally agreed that wind and other external factors do not induce it. Cooper (1905) appears to have been the first to have thought of conducting laboratory experiments to determine the effect of wind on twist. Howard (1932) observed that when a tree is exposed to wind year after year the crown assumes an oval shape, the trunk being off-centre on the side toward the direction of wind. He suggested that if the wind shifts from left to right consistently the trunks would twist from left to right. Haskins and Moore (1933) induced twist by X-ray irradiation of seed of citrus plants whereby the two seedlings that grew up showed marked left-hand twist in early life, but later became normal. His explanation was that twisting is probably physiological and is due to X-ray induced abnormal mitoses lasting through the early stage.

An interesting anatomical explanation of how twist develops during growth has been put forth by Kohl (1933). He draws attention to how the cambial cells divide by a radial cell-plate and transversely by an oblique plate. This oblique cell wall seems to determine the pitch of the path they take in elongation, that is, diagonally around the tree, since it is a path of least resistance. He concludes that it is natural to assume genetic variation in spiral grain in parent and progeny and consequently in any stand of timber trees.

Working with wheat, McKinney and Sando (1934) demonstrated an interesting effect of photoperiod relative to the phenomenon of twist. Under short photoperiods wheat plants of the variety Harvest Queen, a Siberian spring wheat, developed twist in both directions. They opine that it seems reasonable to assume that twisting in wheat or trees is due to heritable factors. "Granting that the character of twisting is due to heritable characters, the expression of the character may be due to the environment". They suggest further experiments with tree seedlings under controlled light conditions, and along a north-south line, i.e., at different latitudes with naturally varying daylengths.

Richens (1945) reviewing the world's literature on forest tree breeding and genetics concludes from his reading of various authors that there can be little doubt that both environmental and genotypic factors are relevant and that spiral graining is produced by an appropriate interaction of both factors.

A finely illustrated popular article on "the Mystery of twisted Trees" by Sears (1950) makes interesting reading.

Kadambi (1951), in a paper presented to the VIII Silviculture Conference 1951 deals along with twisted fibre, the occurrence of what is called interlocked fibre in trees. He draws attention to interlocked fibres, that is, fibres oscillating from left to right and back again and so on around the axis, which is particularly seen in *Poeciloneuron indicum* and *Mesua ferrea*. He also thinks that twist can probably be detected in seedling stages and makes the interesting suggestion that it may possibly be detected even in the embryo. If his conjecture is correct it offers hope of selection of straight-grained trees at the seedling stage and earlier and culling undesirable twisted individuals in the nursery-bed stage.

PLANTS IN WHICH TWIST OCCURS

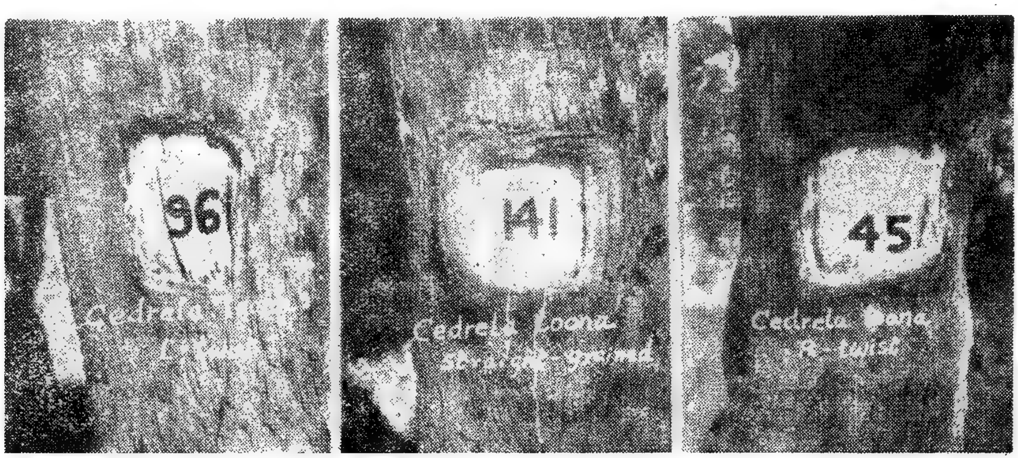
The following list comprises species in which twist has been recorded. Undoubtedly many more genera and species occur showing this phenomenon.

Abies spp.
Acer oblongum
A. platanoides
Aesculus spp.
Alnus spp.
Amelanchier spp.
Bauhinia vahlii
Betula spp.
Boswellia serrata
Carpinus spp.
Castanea spp.
Casuarina equisetifolia
Cedrela toona
Citrus spp.

Dipterocarpus indicus
Dysoxylum malabaricum
Eucalyptus spp.
Eugenia spp.
Fagus spp.
Garuga pinnata
Hardwickia binata
Hopea parviflora
H. wightiana
Juglans spp.
Juniperus virginiana
Larix spp.
Liriodendron spp.
Mangifera indica
Mesua ferrea
Palaquium ellipticum
Picea rubra
P. sitchensis
Pieris ovalifolia
Pinus divaricata
Pinus excelsa
P. jeffereyi
P. longifolia
P. monticola
P. ponderosa
P. radiata
P. resinosa
P. strobus
P. sylvestris
Poeciloneuron indicum
Populus spp.
Pseudotsuga douglasii
Punica spp.
Pyrus communis
P. malus
Quercus spp.
Rhododendron arboreum
Robinia spp.
Salix alba
S. tetrasperma
Shorea robusta
S. talura
Syringa vulgaris
Tectona grandis
Terminalia tomentosa
Thuja occidentalis
T. orientalis
Tilia grandiflora
Triticum spp.
Ulmus spp.
Xylia xylocarpa

TWIST IN CEDRELA TOONA

The author of this paper was struck by the observation of twist in a number of *toon* trees in Dehra Dun, along the Chakrata Road forming a shady avenue in summer. These trees have been marked by rather deeply cut square areas on the trunk in which are inscribed the tree numbers with black paint on white background. Old 'blazes' of this kind with callus growth invading the painted numbers are periodically freshened by still wider and deeper cuts. This practice afforded a good opportunity to see the twisted fibre of the wood underlying the bark, which in this species often reveals the twist on the surface. The accompanying photographs show how clearly the twisted grain is visible even under the white painted blaze (photo).



Out of 484 trees observed along three miles of road with almost continuous avenue of this species, the following numbers were observed.

	No.	Percentage
Straight-grained ..	337	69·6
Left-handed twist ..	74	15·3
Right-handed twist ..	73	15·1
TOTAL ..	484	100·0

The trees represent individuals of different ages having been planted at various times as replacements of dead trees. Thus they do not represent a single age-group or source of seed.

Yet it was remarkable to find nearly the same ratio in different sections of the road which seems to suggest that twist in *toon* conforms to these ratios. We can only conjecture whether these ratios which can be rounded off to 70 : 15 : 15 reveals an underlying genetic trend occurring throughout a population of *toon* trees. If as Kadambi suggests, the twisted nature can be detected in *toon* at the seedling stage, the genetic trend can probably be determined in a relatively short time, by raising progenies of self-pollinated seeds.

The problem of the genetic nature of twist could probably have been easily demonstrated in the case of agricultural crops. The author, however, has not come across any such records. Should it be discovered that in agricultural crops twist is gene-controlled by one or more genes, the concept should be readily applicable to tree species. During the course of tree breeding work which has been started in many countries of the world, the genetic pattern underlying twist in different species should become revealed. Elimination of the undesirable twist should then fall in line with the tree breeder's other objectives, to be won with the tool of genetics.

NOTE BY DR. K. KADAMBI

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I read with great interest the article contributed by Dr. H. S. Rao to the *Indian Forester* entitled "The phenomenon of twisted trees", published above. An outstanding example of twist in nature which, as is well known, is of hereditary origin and distinguishes human races from one another is curly hair. Twist is present in nature in almost every growing body; in fact, in our forests there is probably no tree or plant which is perfectly straight-grained. It is merely the degree of twist that matters.

To the long list of tree species in which twist has been noticed, given in Dr. H. S. Rao's paper, I wish to add the following :—

Wattles – especially *Acacia dealbata* and *A. decurrens*, *Acacia arabica*, *Cassia fistula*, *Calophyllym elatum*, *C. wightianum*, *Canarium strictum*, *Cryptomeria japonica*, *Dillenia indica*, *D. pentagyna*, *Cupressus torulosa*, *Eucalyptus* spp. particularly *Eucalyptus citriodora*, *E. rostrata*, *E. robusta*, *E. globulus*, *E. saligna*. *Ficus* spp. especially – *Ficus bengalensis*, *F. religiosa*, *F. glomerata* Roxb., *Gmelina arborea*, *Hopea glabra*, *Kingiodendron pinnatum*, *Polyalthia coffeoides*, *Pyrus pashea*, *Terminalia paniculata*, *T. chebula*, *T. belerica*, *Palms*.—Arecanut, Cocoanut, Borassus palm and the climbing palm *Calamus thwaitesii*.

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JOHNS MANVILLE – JARRATT, VA. U.S.A.

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INTRODUCTION

This article describes in detail the working of one of the most modern and up-to-date board manufacturing plants in the United States that I had the opportunity of visiting. Johns Manville, Incorporated operates twenty plants in the various parts of United States and Canada with two plants in Belgium and Africa. The Jarratt Plant in Virginia is engaged in the manufacture of insulation board products used as exterior sheathing, plaster lath, decorative interior finishes, roof insulation and acoustical panels. Preformed into a variety of shapes for interior application are the glaze coated ceiling and wall panels, having a smooth surface and soft pastelcolours.

The plant was originally designed to produce 300,000 square feet of ½″ thick boards per day, but through improved methods, better operation and up-to-date machinery, an average of 530,000 square feet are now being produced per day.

ORGANIZATIONAL DETAILS

The plant operates under a straight line and staff organizational set up. The staff consists of a Plant Manager, a Plant Engineer, an Industrial Engineer assisted by two other Industrial Engineers working under him, an Industrial Relations Manager, a Quality Control Manager assisted by Chief Chemist and Assistant Chemist, a Purchasing Officer, a Finance Department Head, a Finishing Department Head and a Chief Forester assisted by two field Foresters.

The manufacturing department is supervised by the Plant Manager. Besides these, there are Foremen in most of the Departments.

There are 475 workers employed at the Jarratt Plant at present. The plant operates around the clock, with three operating shifts and one additional relieving shift. Each employee works an 8 hours day and 40 hours week. A standard set of time has been worked out by the Industrial Engineering Department and an incentive payment plan set up. The starting rate of a production worker varies from $1·15 to $1·20 (equal to approximately Rs. 5/4/- to Rs. 5/8/-) per hour.

The company offers Group Life, Health, Accident and Hospitalization Insurance to its employees at greatly reduced premium rates. There is besides, a retirement plan for all regular employees and a vacation with pay for one week a year as minimum. Among the other subsidiary benefits may be listed the purchase of any Johns Manville Building material at a considerable discount and access to Club House facilities and privileges as members of the Johns Manville Club.

RAW MATERIAL

The mainstay for the board manufacture at the Jarratt Plant is loblolly pine. A small percentage of Oak and Gum is also used (10%) but both of these are considered poor raw material on account of the short fibre length. Softwoods are generally preferred to hardwoods and since loblolly pine is the commonest species available in the vicinity of the plant, it is utilized to the maximum.

Wood is purchased in 5 feet long bolts down to 3 inches diameter. On an average, 200 cords (1 cord = 128 c. ft.) of pine are used per day. Wood is received in the yard by truck and rail (in the proportion of 75% to 25%) and stored in the open until used. The present radius from which the raw material is obtained is stated to be 150 miles. The company

owns approximately 43,000 acres of timber land which are periodically exploited as per the management program detailed later in this article.

MANUFACTURING PROCESS

1. *Physical Plant*—The Jarratt Plant covers an area of 242,080 square feet or approximately 5½ acres. The building is of straight line, single storeyed construction, well ventilated and lighted on the inside (Photo 1). There is considerable amount of moving space all over

PHOTO 1.

Johns Manville—Jarratt, Va. U.S.A.

Photo by :
K. P. Karamchandani.

PHOTO 2.

Steel link conveyor chute from lumber yard to slasher house.

Photo by :
K. P. Karamchandani.

the plant. The lumber yard is also well spaced out with a steel link conveyor chute running right from the unloading platforms to the slasher house (Photo 2).

2. *The Process*—The board at this plant is prepared by the wet continuous process, very similar to paper manufacture. Bolts are conveyed from the wood yard in a chain link chute conveyor to the slasher house where they are cut into 2½ feet lengths by means of circular cross-cut saws set on a moving roller-cum-chain conveyor. The 2½ feet bolts go to a circular drum barker where the bark is removed after softening with a spray of water. The friction in the barker loosens the bark from the bolts, which falls through the openings in the barker and is conveyed to the steam boilers after passing through a hog and used as fuel.

The debarked bolts pass on a chain conveyor to the soaking tanks, where they are softened by a weak solution (2% concentration) of caustic soda for a period 14–16 hours. The exothermic reaction generates a certain amount of heat which facilitates softening. Caustic soda also serves the purpose of extracting some of the resin contained in the pine.

The softened bolts are then conveyed to the grinders after draining the tanks, washed frequently with a spray of water to remove traces of caustic soda and ground on four 48 inches diameter grinding stones, two on each side of the conveyor. The wood bolts are fed from the pockets located on each side of the grinding stone and the ground pulp mixed with water is conveyed to the screens.

Larger particles of improperly ground wood are removed by the screen and reground in a hammer mill. The pulp passing through the screen in a slurry, goes up into the flat screens on the decker floor for final screening. After the final screening, water is removed from the pulp slurry by a revolving screen cylinder, resulting in the pulp sticking on the outer surface of the decker screen. This semi-removal of water serves a dual purpose (*a*) facilitates inspection and (*b*) improves quality. Fresh water and the sizing chemicals, alum sulphate and sodium hydroxide (½ per cent of the dry weight of fibres) are then added to the pulp and stirred in the stock chests.

5′ Bolts → Cross-cut to 2½′ Bolts → Debarking → Soaking in 2% NaOH → Grinding into Pulp ↓

Hammer Mill ⇄ Screening ↓

Ripping by length ← Drying ← Cross-cutting of Sheets ← Steel Rollers ← Sheet Forming Machine ← Decker Screening

↓ Ripping by width → Clay Sizing → One Coat of Paint → Drying → Second Coat of Paint → Drying → Ripping ↓

Shipping ← Packing ← Subsidiary Machining

FIGURE 1.—*Flow Chart of the Manufacturing Process.*

The pulp is now ready for formation into boards. Water from the refined pulp slurry is removed and the fibres reconstituted into a sheet on an Oliver forming machine which consists of a revolving screen on a vacuum cylinder. Water is further removed as the sheet passes through a series of eight steel rolls, which are pneumatically controlled. The board at this stage consists of about 20–25% moisture and the continuous sheet is cut off at any desired length, up to 16 feet, by an automatically controlled saw. Since the continuous sheet keeps moving, the saw cuts at an angle in order to give a straight line edge. Also the sides are trimmed by a forcible stream of water as the sheet leaves the steel rolls.

The strips of board, cut to convenient lengths, are further dried by passing them through a dryer on driven rollers. The dryer is 420 feet long and it takes approximately two hours for

a board to reach the other end. This time period varies with the thickness of the board. The temperature in the dryer is continuously increased as the board passes from moist to dry condition. The wet end of the dryer is maintained at 250°F. and the dry end at 350°F.

As the board strips come out of the dryer, they are again trimmed and cut into several pieces, usually four or six (depending on later usage) on a pair of circular rip saws, set at right angles to each other. One set of rip saws cuts the board lengthwise and it comes out of the dryer, and the second crosswise after the above operation (vide plant layout, Figure 1). The pieces are spread with a slight amount of water to condition the boards.

The board pieces are stacked on hand trollies and moved to the coating machines, where they are either painted with a fire resistent mixture such as clay and casein, or with a waterproof compound such as asphalt (placed in chest when making asphalt board), depending on the usage of the board. Two coats are generally applied to the top surface of the board, which is passed through a dryer after each coating. Four different colors of paint are used at present, e.g., white, ivory, rose tan and grey tan. The coated pieces of board are then ripped to required size.

SUBSIDIARY MACHINING OPERATIONS

In addition to the above manufacturing process, the plant is equipped with a number of other machines for preparing the insulation board pieces for direct use either as wall panels, roof sheathing, or acoustical panels. These consist of the following machines.

(1) Multiple rip saw or Luther machine, where boards may be cut to different sizes longitudinally.

(2) Slat bed machine, which serves the same purpose as the above, except that pieces may be cut in any direction.

(3) Challoner machine, where the board edges are tongued and grooved for direct use as planks. This machine also cuts strips to be used for insulation purposes in the manufacture of refrigerators.

(4) Drilling machine, which drills holes. 484 holes per 12 feet × 12 feet of board, for use as acoustical tile for sound absorption.

(5) Plank machine, which cuts joints and beads on planks.

(6) Wrapping and sealing machine, where the boards are automatically wrapped or packages sealed and made ready for shipment.

INDUSTRIAL ENGINEERING ASPECTS

Quality control—Detailed inspections of the raw material and of the board at the various stages of its manufacture are made to obtain board which meets the company's specifications. In the raw material stage, random samples of wood are taken for determining its density, fibre strength properties and moisture content. After the wood has been ground up, samples are taken and tested for drainage rate, pulp strength wet strength and solid contents. Similar tests are again performed after the refining of the pulp, and the addition of sizing materials. Here pH testing is also done. Specifications require pH to be maintained between 5 and 5·2 after addition of alum and between 6 and 6·5 after addition of sodium hydroxide.

When the board has been formed and trimmed at the tipple, sample pieces of the sheets are tested for thickness, density, tensile strength and water expansion. A complete series of physical property tests, inclusive of the nail holding properties of the board are again performed when the board has been finally dried and ripped to proper sizes.

It is the responsibility of the Quality Control Manager assisted by the Chief Chemist and Industrial Chemist to control the quality of the finished product. The above tests are performed hourly, and although the sampling is based on a time schedule, it constitutes adequate control at every stage of the board manufacture. Material that does not meet the required specifications is rejected and goes through the process over again.

Some control charts on the density and thickness range and on the daily rejections are maintained by the Quality Control Manager. The latter are based on total production basis. Overall rejections are stated to be 5%.

In the field of material handling, the plant is remarkably equipped with mechanical roller conveyors except in the final stages of reprocessing board for direct use and packing, where a ford truck and hand cars are used.

The plant is well ventilated and illuminated both by fluorescent lighting and natural lighting. There is ample aisle space all over the plant.

STORAGE, SHIPPING AND MARKETING

The plant has a spacious warehouse section on the eastern side with one million square feet of board storage space. Transport to markets is mostly done by railroad. The plant has a loading platform on the southern side and packaged material is directly loaded into the railroad cars. Fifteen cars can be placed on the platform at one time.

Marketing is done through the Sales Manager. There are 12 sales representatives in the United States. Nation wide advertising is done through local papers, magazines and radio broadcasts.

POWER SUPPLY

In addition to the electricity which is used for running the machinery at the plant, considerable use is made of steam for heating purposes. The plant is equipped with four boilers. Two are large size Detroit Rotograte Stoker Boilers with steam producing capacity of 75,000 pounds of steam per hour, and the two smaller ones have a steam producing capacity of 24,000 pounds of steam per hour. Two million pounds of steam are generated per day. One hundred tons of coal per day is required for the boilers. Bark obtained during the debarking operation is also used in the boilers to prevent its wastage.

MANAGEMENT OF COMPANY OWNED FORESTS

The company owns approximately 43,000 acres of Forest land which is under the management of the Chief Forester. The forests have been divided into two categories :—

(1) Pure Pine forests (approximately 26,400 acres – Photo 3).

(2) Mixed pine and hardwood forests.

Since the hardwoods are almost useless at present for board manufacture, the management program aims at gradually converting the mixed pine – hardwood forests into pure loblolly pine forests by eliminating the hardwoods.

Two methods of realizing this are being attempted :—

(1) Increased artificial reforestation.

(2) Poisoning of hardwood species.

Results of both these methods for the past six years have been very successful. Poisoning of hardwood by 2–4–5–T after frilling has killed many hardwood species and the blanks are being filled up by reforestation. In other areas discing is done prior to reforestation, which has yielded superior results. With gradual elimination of hardwoods and increased reforestation he company hopes to be self-sufficient in its supply of raw material by 1976.

PHOTO 3

Pure Pine Forests of the Company at Jarratt, Va. with natural regeneration in the foreground.

Photo by:
K. P. Karamchandani.

Experiments are being made with some exotic species which are found to have a short rotation and are found suitable for board manufacture. Among them are a willow species (natural habitat Denmark) and cotton wood. The growth of slash pine in the locality is also being watched in a 12-year old experimental plantation plot of slash pine and loblolly pine (Photo 4). So far the growth of slash pine has been extremely good.

PHOTO 4

A 12 year old mixed plantation of loblolly pine and slash pine at Jarratt, Va.

Photo by:
K. P. Karamchandani.

INDIA'S SECOND SOIL CONSERVATION CONFERENCE

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The Soil Conservation Society of India was formed in 1951 and has just held its second conference. It was inaugurated in Hazaribagh, which is also the headquarters of the Society in December 1951. The first annual meeting was held at Delhi in 1952 and the second at Poona on the 28th to 31st December 1953. Apart from the office-bearers of the society and a large and energetic group of local workers, many of whom contributed papers on their special subjects and activities, the meeting was attended by a number of members and delegates drawn from many parts of India, Burma, T.C.A. and Colombo Plan men working in India, and several senior administrators from Delhi.

The conference was opened officially by Shri Morarji Desai, the Chief Minister of Bombay State, with an excellent address in Hindi, giving his own experiences and summarizing the cultivators' point of view towards the activities of specialists and research workers, quoting instances from Bombay's experience in the operation of soil conservation measures carried out as famine relief in the first instance and now standardized on the basis of that earlier experience and of subsequent research, so that now the services of the contour bunding staff are much in request with an undertaking to repay the cost on a fifteen years' refund of a loan from government to the cultivator.

The proceedings were divided into sections, but these did not meet at the same time, so everyone was enabled to attend them. The first session comprised Agronomy, with several excellent short summaries of local activities of the Dry Farming Research and Bombay Agricultural staffs. The second was on Soil Conservation Engineering, and the third and most actively controversial was on Soil Survey and Planning under the chairmanship of Dr. J. K. Basu, who is the driving power behind much of the successful local marriage between research and field practices.

An afternoon session on the social and economic aspects had very little prepared material but called forth a number of valuable comments from Dr. V. Nath on the somewhat gloomy analysis of the 5-year Plan workers as to the decrease in the size of individual farm holdings; from Mr. M. R. Yardi on the enormous cost to the State if the whole of the Bombay scarcity districts are to be given adequate insurance against crop failures by introducing all of the recommended soil conservation and better farming practices; and a somewhat more cheerful picture from Mr. S. L. Roy on the influence of the recently established agricultural extension schools which are a feature of the 5-year Plan to ensure that the Community Development Projects throughout the country are provided with trained field workers. The last session was on forestry and produced a somewhat scrappy collection of papers and comments on various unrelated aspects of silvicultural and plant breeding research, and a longish statement in which as sectional president I attempted to show the need for including some elementary forestry, afforestation, grazing control, and animal management into the training of the lowest grade of contact worker in the field. In fact "agriculture extension" is not enough and must be expanded into *soil conservation extension*.

Excursions formed part of the meeting's programme, and included an afternoon visit to Kondapuri, an area about 27 miles out of Poona recently covered by the now standardized field bunding. This is well worth study for its possibilities in water conservation for cropping in unirrigated upland, but obviously needs adjustment to local conditions and cannot be applied elsewhere without very careful amendment. The method has undoubtedly been improved since the efforts of the early 1940's which aimed at a quick famine relief task over

some 600,000 acres of the "scarcity" districts, but one thing that struck me most forcibly was the continuity of the system worked out then and since continued with some improvements. If one believed everybody's statements, including those of the politicians, the early work done under the Section 93 rule by the forest officers working under the Director of Agriculture, Sir William Jenkins, had all to be scrapped and a fresh start made, but in actual fact this was not so, and these early efforts have been continued and only slightly altered in details of survey and construction. The main improvement since then has been in a better preparation by means of propaganda and instruction by which village groups are persuaded of the soundness of the work before it is brought to their area. But the proof of the pudding is in the eating, and by the time Section 93 rule was done away with, the cultivators were beginning to appreciate the value of the bunding as an insurance against crop failures.

The longer excursion to the Sholapur Dry Farming Research Station entailed a night's train journey but was well attended, and in the course of visiting the various sections and laboratories there were many useful and animated discussions. Possibly the most interesting part from the forester's point of view was the range of plots showing the local grasses and legumes which were under trial as ground covers and pasture mixtures; also the many vivid posters worked out to impart the lessons and data from research work. I was also personally much impressed with the steady advances which have been made in the lay-out and instrumentation of the various run-off measurement plots since I saw these in 1946. The Sholapur station is now one of the best training grounds for learning the technique of water use by plants and water conservation by crops and various ground covers, and is being increasingly used as such, the latest batch of trainees being from the Shan States of North Burma.

Amongst the delegates were a number of foresters from various states, and from the interest taken in the forestry session there is a growing awareness amongst other soil conservation workers of the contribution which forestry can make to the common problem. One rather lamentable feature was what appeared to be a boycott of the meeting by the local foresters who were only represented in the last session, and that only as a result of an order from the Chief Minister. One would have thought that an opportunity of this sort would have been welcomed for the contacts with fellow-foresters apart from the value of the meeting in furthering the younger science of soil and water conservation.

The journal of the society has now reached its sixth issue as a quarterly, and has achieved an exceedingly high standard both in reproduction and in the quality of the contributed papers. For this alone, membership of the society can be strongly recommended to all forest officers and rangers. It is planned to have sample copies of the journal issued through Chief Conservators so that the work of the society can become better known and supported by professional foresters.

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PHENOLOGICAL BEHAVIOUR OF A FEW FOREST SPECIES AT NEW FOREST, DEHRA DUN

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(Continued from the *Indian Forester*, March 1954, page 153)

(*ii*) *Beginning of new leafing in Cedrela toona*

Average date of beginning of new leafing = 38 (7th February).
Date of beginning of new leafing in 1931 = 24 (24th January).
Do. do. 1930 = 30 (30th January).
Do. do. 1934 = 45 (14th February).
Do. do. 1942 = 45 (14th February).
Do. do. 1943 = 48 (17th February).

(*a*) *Mean temperatures*

1931. The year's mean temperature curve during January lies well above the periodic average curve and the differences during the first three weeks range between 3° to 5°F.

1930. Excepting for the third week of the month, the year's mean temperatures during January were considerably higher than the average values.

1934. The year's mean temperatures for the second, third and fourth weeks of January and the first week of February were 2° to 6°F. lower than the average values for the period.

1942. The mean temperature values during January and first week of February were throughout 1° to 3°F. lower than the periodic averages.

1943. The year's curve lies below the periodic average curve by 1° to 3°F. from third week of January to the third week of February.

(*b*) *Rainfall*

Year	Rainfall from 1st December of the previous year till				Date of occurrence of phenomenon
	January 14	January 21	January 31	February 14	
1931	1·20	1·20	..	..	24th January
1930	7·69	9·02	9·62	..	30th „
1934	3·85	3·85	4·05	4·05	14th February
1942	0·56	4·55	4·55	5·04	14th „
1943	5·62	5·62	5·92	7·18	17th „
Average for the period 1928–43	2·19	2·97	3·93	5·41	7th „

(*c*) *Humidity*

1931. Humidity during January was considerably lower than the periodic average figures.

1934. Excepting for the first week of February the year's humidity curve lies above the periodic average curve from the first week of January till the second week of February.

1942. The year's humidity curve lies well above the average curve during January and February.

1930 and *1943* data are not available.

Conclusions

High values of mean temperature and low relative humidity induce early leafing in the case of Cedrela toona. As opposed to this low values of mean temperature and high humidity delay the phenomenon. Winter rainfall does not appear to have a clear correlation with the phenomenon.

(*iii*) *Beginning of new leafing in Dalbergia sissoo*

Average date of beginning of new leafing			= 56 (25th February).
Date of beginning of new leafing in		1934	= 46 (15th February).
Do.	do.	1932	= 47 (16th February).
Do.	do.	1928	= 62 (2nd March).
Do.	do.	1943	= 62 (3rd March).
Do.	do.	1942	= 69 (10th March).

(*a*) *Mean temperatures*

1934. Mean temperatures during the last three weeks of January and the first week of February were appreciably less than the periodic average values. They shot up to about 5°F. above the average values during the second week of February and remained well above them for another two weeks.

1932. The year's mean temperatures were 3° to 4·5°F. above the periodic average values during January and the first week of February. During the second week of February both were practically the same.

1928. The year's curve follows the periodic average curve fairly closely from the last week of January till the third week of February, the differences never exceeding 1½°. It registers a sharp rise of about 3°F. during the next two weeks.

1943. With the exception of the fourth week of February the year's mean temperatures from middle of January till the middle of March were 1° to 2°F. lower than the periodic averages.

1942. Excepting for the second week of February, the mean temperatures during the period January to the first week of March remained below the periodic averages by 1° to 3°F.

(*b*) *Rainfall*

Year	Rainfall from 1st December of the previous year till			Date of occurrence of phenomenon
	January 31	February 15	February 28	
1934	4·05	4·05	..	15th February
1932	Nil	0·49	..	16th ,,
1928	5·96	10·58	10·93	2nd March
1943	5·92	7·18	7·18	2nd ,,
1942	4·55	5·04	10·08	10th ,,
Average for the period 1928–43	3·93	5·41	6·59	25th February

(*c*) *Humidity*

1934. From January to second week of February the year's relative humidity figures were on the whole higher than periodic averages.

1932. Humidity during second half of January and the whole of February was remarkably lower than average.

1942. The year's relative humidity curve runs well above the periodic average curve from early January till the third week of March.

1928 and *1943* humidity data are not available.

Conclusions

An examination of the above data indicates that high temperatures and low relative humidity from the end of January to the middle of February and low winter rainfall advance new leafing in Dalbergia sissoo at New Forest. As opposed to this, low temperatures and high humidity from end of January onwards and heavy winter rainfall tend to delay the phenomenon. The fluctuations in the time of occurrence of the phenomenon in any particular year are probably controlled by the inter-action of these important factors (along with some minor ones, perhaps) and may be difficult to explain on the basis of only one or two of them.

(*iv*) *Beginning of new leafing in Mangifera indica*

Average date of beginning of new leafing = 88 (29th March).

Date of beginning of new leafing in 1928 = 73 (13th March).

Do. do. 1930 = 77 (18th March).

Do. do. 1937 = 110 (20th April).

Do. do. 1943 = 130 (10th May).

(*a*) *Mean temperatures*

1928. Except for the last weak of January, the year's curve lies above the periodic average curve throughout winter. There was a marked spell of warm weather during the last week of February and the first week of March when mean temperatures were about 3°F. above the average.

1930. After fluctuating around the periodic average values till the second week of February the year's curve shoots upwards during the third week of the month, continues to rise in the next week and starts declining from the first week of March. The differences during the peak period are as high as 4° to 6°F. After touching the normal curve in the second week of March it again starts rising.

1937. The year's curve lies well below the periodic average curve from the third week of February till the second week of April – the difference from the third week of March till the second week of April varying from 3° to 6°F. The beginning of the phenomenon on the 20th of April is preceded by a week's spell of comparatively warmer temperatures.

1943. With the exception of the fourth week of February and third week of March, the year's mean temperature values from February onwards were lower than the periodic averages. The differences during the last three weeks of April especially ranged between 3° to 6°F. and those during the first two weeks of May between 2° to 3°F.

(*b*) *Rainfall*

Year	Rainfall from 1st December of the previous year till						Date of occurrence of phenomenon
	February 28	March 14	March 31	April 14	April 30	May 7	
1928	10·93	11·49	..	..	..	..	13th March
1930	12·70	13·54	..	..	..	..	18th „
1937	11·64	11·64	11·84	13·10	..	..	20th April
1943	7·18	7·18	8·18	9·51	10·14	10·14	10th May
Average for the period 1928–43	6·59	7·21	7·59	7·88	8·23	8·45	29th March

(*c*) *Humidity*

Humidity data, unfortunately, are available only for 1937. During this year relative humidity fluctuated round the periodic average figures in February and March and was consistently higher from the last week of March onwards. As the rainfall was above the average during all the remaining three years it would be safe to assume that humidity % also was not appreciably lower than the average during the periods under consideration.

Conclusions

It appears that, out of the three climatic factors discussed above, temperature alone exercises an appreciable effect on the date of new leafing in Mangifera indica. A spell of warm weather during the second half of February and the beginning of March advances the phenomenon while lower temperatures during February, March and April have the opposite effect.

(*v*) *Beginning of new leafing in Shorea robusta*

Average date of beginning of new leafing = 90 (31st March).
Date of beginning of new leafing in 1935 = 63 (4th March).
Do. do. 1933 = 64 (5th March).
Do. do. 1943 = 109 (19th April).
Do. do. 1942 = 116 (26th April).

(*a*) *Mean temperatures*

1935. The mean temperatures during February were generally above the periodic average values with a pronounced peak of nearly 3·5°F. during the second week of the month. They showed a downward trend towards the end of the month and were 2·5°F. below the normal in the first week of March.

1933. There was a spell of warm weather during the first two weeks of February after which the temperatures returned more or less to the normal and then fell below the normal during the first week of March.

1943. With the exception of the fourth week of February and the third week of March the year's mean temperature values from February onwards were much lower than the periodic averages.

1942. The year's temperature curve, as compared with the periodic average curve, does not show any sharp depressions in January. During the last two weeks of February and the first week of March, it lies about 1½°F. below the average curve, crosses it in the second week of March, and remains 1° to 3°F. above it till the second week of April.

(*b*) *Rainfall*

Year	Rainfall from 1st December of the previous year till				Date of occurrence of phenomenon
	February 28	March 31	April 14	April 21	
1935	7·34	..	..	..	4th March
1933	5·76	..	..	..	5th ,,
1943	7·18	8·18	9·51	9·51	19th April
1942	10·08	10·64	10·64	11·76	26th ,,
Average for the period 1928–43	6·59	7·59	7·88	8·08	31st March

(*c*) *Humidity*

1935. Relative humidity was higher during the last week of January and the first three weeks of February, became equal in the last week of February and lower in the first week of March.

1933. Relative humidity was a little less than normal in the first three weeks of February, higher in the last week of the month, and again became a little below the average in the first week of March.

1942. The year's curve lies well above the periodic average curve from the beginning of January till the third week of March, follows more or less the normal course during the next three weeks and again shoots up in the middle of April.

1943. Humidity data are not available.

Conclusions

The rainfall and humidity data examined above do not suggest any clear correlation between these factors and the beginning of new leafing in the case of Shorea robusta. Mean temperatures, however, appear to have more pronounced effect. A warm spell in February appears to induce early leafing while low temperatures in February, March, April tend to delay the phenomenon. The year 1942 does not fit in well in this pattern suggesting thereby that some other factors must be more influential in that case.

(*vi*) *Beginning of flowering in Albizzia procera*

Average date of beginning of flowering = 217 (5th August).
Date of beginning of flowering in 1929 = 203 (22nd July).
Do. do. 1941 = 207 (26th July).
Do. do. 1943 = 229 (17th August).
Do. do. 1940 = 232 (19th August).

(*a*) *Mean temperatures*

1929. The mean temperatures during April, May, June and the first half of July were higher than the normal by 1° to 4°F.

1941. The mean temperatures during the period March, April and the first week of May were very much higher than the average values. There were two sharp depressions during the second and third weeks of May and the first three weeks of June. The temperatures

rose above the normal in the subsequent week and again fell in the first week of July. The year's curve during the remaining three weeks of July lies above the periodic average curve.

1943. Mean temperatures during the periods April to August, with one single exception during last week of June, were consistently below the average values.

1940. The year's mean temperature curve lies below the periodic average curve during March and April and shows only minor fluctuations from May onwards.

(*b*) *Rainfall*

Year	Year's rainfall till							Date of occurrence of phenomenon
	April 30	May 31	June 30	July 14	July 21	July 31	August 15	
1929	3·61	3·95	7·81	11·87	18·73	..	..	22nd July
1941	3·91	8·81	15·55	21·29	25·35	..	..	26th ,,
1943	7·88	9·72	13·99	28·55	33·03	38·83	66·69	17th August
1940	10·53	14·01	24·83	33·79	39·53	49·83	57·60	19th ,,
Average for the period 1928–43	6·87	8·78	17·06	27·15	33·14	43·27	57·98	5th ,,

(*c*) *Humidity*

Humidity figures for 1929 and 1943 are not available. The position in 1941 and 1940 was as under :

1941. Relative humidity during May and the first three weeks of June was considerably higher than the average, it was lower in next week and showed only minor fluctuations after that.

1940. Relative humidity was appreciably lower during the first three weeks of May and very much higher after that till the middle of August.

Conclusions

While high temperatures preceded the early occurrence of this phenomenon in 1929 and low temperatures preceded its late occurrence in 1943, there was no similar marked tendency in 1940 or 1941. Relative humidity figures are available for only two out of the four years under examination and do not suggest any marked correlation between humidity and the date of flowering. As opposed to these, the rainfall during June and July was considerably less than normal in the years of early flowering and more than normal in years of late flowering. It, therefore, appears that excess of rainfall during June and July coupled probably with low temperatures, delay the flowering of Albizzia procera, while low rainfall and high temperatures have an opposite effect.

(*vii*) *Beginning of flowering in Cedrela toona*

Average date of beginning of flowering = 80 (21st March).
Date of beginning of flowering in 1932 = 68 (8th March).
Do. do. 1931 = 70 (11th March).
Do. do. 1936 = 87 (27th March).
Do. do. 1939 = 87 (28th March).
Do. do. 1940 = 95 (4th April).

(*a*) *Mean temperatures*

1932. Excepting for the last three weeks of February, the year's mean temperature curve lies well above the normal curve till the end of April, the difference in January and first week of February varying from 3° to 4·5°F. and in the first two weeks of March from 4° to 6°F.

1931. After a spell of warm weather during January, the mean temperatures fell sharply during the second week of February and remained about 3° to 6°F. below the average value till the appearance of phenomenon.

1936. The year's curve lies below the average curve till the first week of February and shows only minor fluctuations after that, till the beginning of the phenomenon at the end of March.

1939. The year's mean temperature curve is above the average curve till the second week of February and from the last week of February till the time of beginning of flowering at the end of March it lies from 4° to 6°F. below the normal values.

1940. The mean temperatures remained 3° to 5·5°F. below the average values during the first two weeks of February, were slightly above the average during the remaining 2 weeks of the month and fell sharply during the first week of March and remained 3° to 5°F. below the normal till the first week of April.

(*b*) *Rainfall*

Year	Rainfall from 1st December of the previous year till				Date of occurrence of phenomenon
	February 28	March 7	March 21	March 31	
1932	·56	·56	..	..	8th March
1931	5·95	7·42	..	..	11th „
1936	1·92	2·13	2·48	2·98	27th „
1939	3·53	3·83	4·16	4·36	28th „
1940	7·67	8·72	9·70	9·90	4th April
Average for the period 1928–43	6·59	6·98	7·30	7·59	21st March

(*c*) *Humidity*

1932. From the third week of January to the first week of March the humidity values were conspicuously lower than the periodic average values.

1931. Excepting for the second and third weeks of February, relative humidity from the beginning of January till the beginning of the phenomenon in the second week of March was considerably lower than the average values.

1936. The year's humidity curve is on the whole lower than the periodic average curve in January, a little higher in February and in the first two weeks of March and dips down in the third week of March.

1939. Relative humidity was lower by 5 to 19% till the second week of February. From this point onwards till the appearance of flowers at the end of March, humidity values fluctuated violently about the average curve.

1940. Relative humidity was 2 to 9% lower in January and considerably higher during the next two months.

Conclusions

Variations in mean temperatures, winter rainfall and relative humidity do not offer a consistent explanation of the early or late occurrence of flowering in Cedrela toona. The year 1932 with the earliest date of flowering experienced high mean temperatures, low rainfall and low humidity during the first 2½ months and 1940, the year of latest flowering, enjoyed low temperatures, high rainfall and high humidity. During 1931, which is second on the list for early flowering, the temperatures were low, the rainfall more or less normal and the humidity also low. Similarly 1936 and 1939, the years with delayed flowering, show different arrangements. It would thus appear that the phenomenon in the case of toon is controlled by more complex factors.

(*viii*) *Beginning of flowering in Dalbergia sissoo*

Average date of beginning of flowering			=	83 (24th March).
Date of beginning of flowering in		1929	=	64 (5th March).
Do.	do.	1930	=	75 (16th March).
Do.	do.	1934	=	75 (16th March).
Do.	do.	1940	=	95 (4th April).
Do.	do.	1936	=	99 (8th April).

(*a*) *Mean temperatures*

1929. From the last week of February till the date of commencement of flowering in the first week of March the year's curve lies 4° to 5°F. above the average curve.

1930. The mean temperature curve shoots up above the periodic average curve during the third week of February and continues to rise in the next week. It starts declining in the first week of March and touches the average curve in the second week of the month. The differences during the peak period (3rd and 4th week of February) are as high as 4° to 6°F.

1934. There was a spell of warm weather during the last three weeks of February when the year's temperatures were 3° to 5°F. above the periodic averages. The temperatures started falling in the first week of March and were about 3°F. below the average in the second week of the month.

1940. The year's curve lies well below the periodic average curve from the first week of March till the first week of April, the differences ranging from 3° to 5·5°F.

1936. Excepting for a rise of 2°F. in the first week of March and an equal fall in the next week, the year's mean temperature curve follows the periodic average curve remarkably closely from the second week of February till the end of March. It shows a considerable depression in the next two weeks.

(*b*) *Rainfall*

Year	Total rainfall from 1st December of previous year till					Date of occurrence of phenomenon
	February 28	March 7	March 14	March 31	April 7	
1929	4·48	..	..	..	..	5th March
1930	12·70	12·91	13·54	..	..	16th „
1934	4·54	5·80	7·27	..	..	16th „
1940	7·67	8·72	9·70	9·90	..	4th April
1936	1·92	2·13	2·48	2·98	3·12	8th „
Average for the period 1928–43	6·59	6·98	7·21	7·59	7·70	24th March

(*c*) *Humidity*

Out of the five years under consideration, humidity data are available only for three. In 1934 the relative humidity was higher during January, on the whole lower during the subsequent 5 weeks and started rising in the second week of March. The 1936 humidity curve runs below the average curve in January, and is on the whole higher during February and the first half of March, but falls below it during the third week of March and again rises in the first week of April. In 1940 relative humidity was less than average during January, rather higher than average in February and appreciably so in March.

Conclusions

Examination of the above data indicates that out of the three climatic factors examined here, rainfall probably plays only a minor part but mean temperatures and humidity appear to have a good correlation with the time of flowering of Dalbergia sissoo at Dehra Dun. High values of mean temperature and low relative humidity from the end of January onwards appear to advance the flowering date while lower temperature values and higher relative humidity, especially in the later part of March and early April, appear to delay the phenomenon.

(*ix*) *Beginning of flowering in Mangifera indica*

Average date of beginning of flowering			=	68 (9th March).
Date of beginning of flowering in		1935	=	43 (12th February).
Do.	do.	1934	=	53 (22nd February).
Do.	do.	1942	=	80 (21st March).
Do.	do.	1937	=	82 (23rd March).

(*a*) *Mean temperatures*

1935. The first three weeks of January were exceptionally cold. Mean temperature shot up in the last week of January and was about 1°F. above the average values for about a fortnight. There was a further steep rise in the second week of February when the difference increased to about 4°F.

1934. After a spell of low mean temperatures during the last three weeks of January and the first week of February, the temperatures shot to 5°F. above the periodic average values, during the second week of February and remained well above them for another two weeks.

1942. Excepting for the second week of February and the second week of March, the year's temperatures were below the average values by 1° to 2°F. from the beginning of January till the third week of March.

1937. The year's curve lies well below the average curve during the first three weeks of January, crosses it in the last week of the month and is about 3°F. above it during the first week of February. The temperatures became normal in second week of February and were lower than the average values by about 2° to 5°F. from the third week of February till the last week of March.

(*b*) *Rainfall*

Year	Total rainfall from 1st December of the previous year till					Date of occurrence of phenomenon
	January 31	February 7	February 21	February 28	March 21	
1935	5·17	5·17	..	..	..	12th February
1934	4·05	4·05	4·54	..	..	22nd ,,
1942	4·55	4·55	9·87	10·08	10·64	21st March
1937	3·94	3·94	7·58	11·64	11·64	23rd ,,
Average for the period 1928–43	3·93	4·69	6·11	6·59	7·30	9th ,,

(*c*) *Humidity*

1935. Excepting for the second and third weeks of January the year's humidity values were higher than periodic averages till 7th February.

1934. Relative humidity during January and the first half of February was on the whole higher than the average.

1942. Relative humidity during January, February and March was throughout higher than the average values.

1937. Excepting for the first and third weeks of February, the 1937 curve lies above the average curve from 1st January till 7th March and falls below it during the next two weeks.

Conclusions

The winter rainfall in all the four years was average or above the average. Similarly the relative humidity values also were higher than the average figures. There does not appear to be any clear relationship between rainfall and humidity and flowering of Mangifera indica at Dehra Dun. The temperature data, however, suggest that low values of mean temperature during February and March delay the phenomenon, while a spell of high temperatures for two to three weeks in February advances it.

(*x*) *Beginning of flowering in Shorea robusta*

Average date of beginning of flowering			=	85 (26th March).
Date of beginning of flowering in		1935	=	69 (10th March).
Do.	do.	1943	=	69 (10th March).
Do.	do.	1930	=	76 (17th March).
Do.	do.	1940	=	100 (9th April).
Do.	do.	1939	=	103 (13th April).

(*a*) *Mean temperatures*

1935. The mean temperatures during February were generally above the average values with a sharp peak of about 4°F. during the second week of the month. They showed a downward trend towards the end of the month and were 2·5°F. below the normal values in the first week of March. There was again a sharp rise in the second week of the month.

1943. The year's mean temperature curve lies below the average curve by 1° to 2°F. during the first three weeks of February. It rises sharply to about 4°F. above the average values during the last week of February, falls equally suddenly during the next week and remains about 2°F. below the average curve for a fortnight.

1930. After fluctuating around the periodic average values till the second week of February, the mean temperatures shot up during the third week of the month and continued to rise during the next week. They started declining in the first week of March and came down to the normal during the second week of the month. The differences during the peak period (third and fourth weeks of February) were as high as 4° to 6°F.

1940. The year's curve lies well below the periodic average curve from the first week of March till first week of April, the differences ranging from 3° to 5·5°F.

1939. The year's mean temperature curve lies above the average curve till the second week of February. It shows a downward trend in the next week and from the last week of February till the time of beginning of flowering in the second week of April it remains 4° to 6°F. below the average curve.

(*b*) *Rainfall*

Year	Total rainfall from 1st December of the previous year till					Date of occurrence of phenomenon
	February 28	March 7	March 14	March 31	April 7	
1935	7·34	7·34	..	..	..	10th March
1943	7·18	7·18	..	..	..	10th „
1930	12·70	12·91	13·54	..	..	17th „
1940	7·67	8·72	9·70	9·90	9·90	9th April
1939	3·53	3·88	4·16	4·36	4·50	13th „
Average for the period 1928–43	6·59	6·98	7·21	7·59	7·70	26th March

(*c*) *Humidity*

1935. Year's values were rather higher in the last week of January and the first three weeks of February, equal in the fourth week of February and lower in first week of March.

1940. Humidity in January was lower than the average values, on the whole higher during February, consistently so during March, and again fell below average in the first week of April.

1939. Relative humidity was lower by 5 to 19% during the period January to second week of February. From middle of February till appearance of flowers in the second week of April the humidity values fluctuated rather violently around the periodic averages.

1930 and *1943* humidity data are not available.

Conclusions

The above data suggest that there is no clear correlation between rainfall and humidity and the beginning of flowering of sal at Dehra Dun. The phenomenon is probably connected more closely with temperature. On the whole the years of early flowering had varying spells of high temperatures before the commencement of flowering in March, though this rise was more pronounced in 1930 than in 1940 or 1935. The years of late flowering were both characterized by low temperatures during March and April. It might thus be concluded that flowering in sal is advanced by high temperatures and delayed by low ones, while changes in rainfall and humidity have no apparent effect.

(*xi*) *Appearance of first ripe fruit in Albizzia procera*

Average date of first ripe fruit			= 91 (1st April).
Date of first ripe fruit in		1937	= 79 (20th March).
Do.	do.	1942	= 79 (20th March).
Do.	do.	1936	= 97 (6th April).
Do.	do.	1941	= 117 (27th April).

As the average date of maximum flowering for this species is 24th August, temperatures have been considered from September of the previous year. Rainfall and humidity figures have been examined from October because the rainfall and humidity – during September are quite high, and the post-monsoon drought period starts from October only.

(*a*) *Mean temperatures*

1937. The 1936 temperature curve is a little lower than the average curve from September till December. The 1937 curve also is below the average curve during the first three weeks of January. It touches the average curve in the last week of January, climbs up by about 3°F. in the next week and sinks down to the average values in the second week of February. From the third week of February till the last week of March, the year's curve runs about 2° to 5°F. below the average curve.

1942. The 1941 curve shows only minor fluctuations from the average curve during the period September to October. Excepting for the second week of February and the second week of March, the 1942 curve lies below the average curve by 1° to 2°F.

1936. During the last four months of the year, the 1935 curve lies below the average curve by about 1° to 3°F. This tendency persists in 1936 till the first week of February. From the second week of February till the end of March the year's curve follows the average curve fairly closely making two small departures on either side in the first and second weeks of March. There is a sharp depression of 2° to 4°F. in the first fortnight of April.

1941. The 1940 curve is 2° to 6°F. below the periodic average curve during September and the first week of October and fluctuates round the average values till the first week of December. Mean temperatures during January, 1941 were less than average values and those during February, March and April, 1941 were distinctly higher.

(*b*) *Rainfall*

Year	Rainfall from 1st October of the previous year till									Date of occurrence of phenomenon
	Oct. 31	Nov. 30	Dec. 31	Jan. 1	Feb. 28	March 14	March 31	April 7	April 21	
	of previous year			of the current year						
1937	1·30	1·30	4·89	5·25	12·94	12·94	13·14	14·40	14·82	20th March
1942	2·73	3·57	3·99	8·12	13·65	14·21	14·21	14·21	15·33	20th „
1936	0	·56	1·19	1·29	2·48	3·04	3·54	3·68	3·75	6th April
1941	·14	·14	·56	3·64	4·06	4·13	4·33	4·33	4·47	27th „
Average for the period 1928–43	1·06	1·24	2·60	5·17	7·83	8·45	8·83	8·94	9·32	1st „

(*c*) *Humidity*

1937. Relative humidity was less than average in the first half of October, 1936 and generally more than average from the third week of October 1936, till end of January, 1937. It fluctuated during the next 5 weeks and was on the whole a little higher than average. The values during the second and third weeks of March were lower than average.

1942. Relative humidity was on the whole above the average values during the last three months of 1941 and consistently so during January, February and March of 1942.

1936. During the last three months of 1935 the relative humidity values from October onwards fluctuated a lot around the periodic averages without showing any clear trend. The 1936 curve shows a marked depression during the last three weeks of January. It fluctuates around the average values from the beginning of February till the second week of April.

1941. With the exception of a depression in the first week of November, the 1940 curve lies above the average from the third week of October onwards. During January and

first half of February, the 1941 curve also runs above the periodic average curve, and lies below it from the last week of February till the first week of April.

Conclusions

It appears that the variations in the date of fruit ripening in the case of Albizzia procera at Dehra Dun cannot be satisfactorily explained on the basis of fluctuations in temperature or humidity during the period of fruit formation. The precipitation is probably the more important factor. Heavy rainfall during the period October to March appears to advance the phenomenon and dificit rainfall to delay it.

(*xii*) *Appearance of first ripe fruit in Cedrela toona*

Average date of first ripe fruits			=	133 (13th May).
Date of first ripe fruit in		1931	=	124 (4th May).
Do.	do.	1942	=	124 (4th May).
Do.	do.	1940	=	138 (17th May).
Do.	do.	1937	=	138 (18th May).
Do.	do.	1939	=	143 (23rd May).

(*a*) *Mean temperatures*

1931. Mean temperatures were lower than average values by 2° to 6°F. during the first three weeks of March and higher by 1° to 5°F. from the fourth week of March till the end of April.

1942. The temperatures were 1° to 2°F. above the normal during the last week of March and the first two weeks of April. There was a sharp fall of about 3°F. below the normal during the third week of April, followed by an equally sudden rise of about 2°F. in the next week.

1940. With the exception of the second week of April, the year's mean temperature curve lies below the average periodic curve from the beginning of March to the first week of May.

1937. With the exception of the third week of April the mean temperatures for the year were considerably lower than the normal temperatures from the end of February to the middle of May, the differences during the last week of April and the first two weeks of May ranging between 3° to 5°F.

1939. The temperatures in March and April were remarkably lower than the average. Those for May are unfortunately not known.

(*b*) *Rainfall*

Year	Rainfall from 1st December of the previous year till				Date of occurrence of phenomenon
	March 31	April 30	May 14	May 21	
1931	7·42	7·42	..	..	4th May
1942	10·64	11·76	..	..	4th „
1940	9·90	10·53	10·53	..	17th „
1937	11·84	13·52	13·59	..	18th „
1939	4·36	4·50	4·50	5·69	23rd „
Average for the period 1928–43	7·59	8·23	8·92	9·28	13th „

(*c*) *Humidity*

1931. Relative humidity from the second week of March till the first week of May, when the first ripe fruit was noticed, was lower than the periodic average values, the difference from the fourth week of March to the first week of May ranging between 8 and 21 per cent.

1942. The year's humidity curve is well above the average curve during the first three weeks of March and shows only minor deviations from it from the fourth week of March till the beginning of the phenomenon in the first week of May.

1940. As compared with the periodic average values relative humidity was appreciably higher during the month of March, lower during the first fortnight of April and again higher during the second fortnight. During the first three weeks of May it was again low.

1937. From the last week of March till the third week of May relative humidity was appreciably higher than the average values.

1939. Humidity was on the whole appreciably lower than the average values during April and May.

Conclusions

Both the years of early flowering had mean temperatures considerably higher than the periodic average values during the five weeks period preceding the time of flowering. As opposed to this the three years of late flowering were characterized by low mean temperatures during the months of March, April and May. No such consistent trends are visible in the case of rainfall and humidity data. It, therefore, appears that fruit ripening in the case of Cedrela toona at Dehra Dun is probably hastened by high mean temperatures during late March and April, and delayed by low mean temperatures from March to May.

(*xiii*) *Appearance of first ripe fruit in the Dalbergia sissoo*

Average date of first ripe fruit			=	311 (7th November).
Date of first ripe fruit in		1936	=	288 (14th October).
Do.	do.	1935	=	298 (25th October).
Do.	do.	1940	=	321 (16th November).
Do.	do.	1942	=	333 (29th November).

(Average date of maximum flowering : 9th April).

(*a*) *Mean temperatures*

1936. Temperatures were well above the average values from the third week of April till third week of May and below these from the fourth week of May till mid-July. They followed the average values quite closely during the next six weeks and were below them by about 1° to 2°F. during September and first half of October.

1935. The year's mean temperatures were well below the average values from mid-April till mid-May, above them during the next 6 weeks, fluctuated round them till the first week of September and remained below them afterwards.

1940. From the second week of May till first week of September, the year's mean temperatures were generally above the periodic average values. They were lower than the average values by 1° to 6°F. from the second week of September to the second week of October, became equal to them in the third week of October, rose by 2°F. in next week and fell below them in the first week of November.

1942. The year's mean temperatures during the period 15th June to November were throughout lower than the periodic averages with two marked depressions in the second and third weeks of August and from end of September to mid-October. During May and first half of June the temperatures fluctuated round the average values.

(b) Rainfall

Year	Year's rainfall till						Date of occurrence of phenomenon
	August 31	Sept. 30	Oct. 14	Oct. 21	Oct. 31	Nov. 15	
1936	81·10	97·74	97·74	..	..	..	14th October
1935	64·63	71·35	71·35	71·35	..	..	25th ,,
1940	66·71	72·36	72·36	72·50	72·50	72·50	16th November
1942	90·87	103·08	103·08	103·08	103·08	103·08	29th ,,
Average for the period 1928–43	70·56	80·79	81·32	81·66	81·85	81·92	7th ,,

(c) Humidity

1936. Relative humidity values were higher than the periodic averages during the first half of September, lower in the third week and normal during the last week of the month. They fell during the next two weeks and remained below the average.

1935. The year's curve, practically coincides with the average curve during the first three weeks of September and is below the latter from the last week of the month till the time of appearance of ripe fruit on 25th October.

1940. The year's curve is about 2 per cent above the average curve during the last three weeks of September, remains below the average values by 3 to 8 per cent during the first fortnight of October and again shoots up to about 5 per cent above the average values during the latter half of October and the first week of November.

1942. Data are not available.

Conclusions

It would be seen that after showing different patterns during the premonsoon and monsoon periods the mean temperatures from mid-September till the time of appearance of first ripe fruit were on the whole lower than average in all four years. None of the years was particularly dry. Years of early and late fruit ripening occur in years of deficit rainfall as well as in years of excess rainfall. The humidity data are available only for three of the years under consideration. These data do not exhibit any clear trends over the long periods between the time of flowering to the time of fruit ripening. Relative humidity was, however, appreciably lower in the preceding 4 weeks in the case of both the years of early fruit ripening and slightly higher in the case of the one year of late fruit ripening for which humidity figures are available. It would be too much to claim clear relationship between the two phenomenona on the basis of this mild indication. Early or late appearance of first ripe fruit in Dalbergia sissoo at Dehra Dun cannot thus be easily explained on the basis of fluctuations in mean temperatures, rainfall and humidity.

(*xiv*) *Appearance of first ripe fruit in Mangifera indica*

Average date of first ripe fruit = 183 (2nd July).
Date of first ripe fruit in 1941 = 161 (10th June).
Do. do. 1938 = 171 (20th June).
Do. do. 1943 = 171 (20th June).
Do. do. 1933 = 194 (13th July).
Do. do. 1935 = 194 (13th July).

(Average date of maximum flowering : 2nd April).

(*a*) *Mean temperatures*

1941. The year's mean temperature curve lies above the average periodic curve from February till the first week of May, the difference in April and first week of May ranging between 2° and 6°F. The temperatures fell steeply in the next week and were 3° to 5°F. below the average for a fortnight. They were again about 1°F. above normal in the last week of May, but fell sharply in the first week of June.

1938. The year's temperatures fluctuated round the average values during March and April. From the last week of April to end of May, the year's curve is consistently higher than the average curve by about 2°F. and falls down steeply in the first week of June, remaining 2° to 5°F. below the average values throughout the month.

1943. During April, May and June the year's mean temperature curve lies below the periodic average curve.

1933. During April to early July the year's temperature curve lies below the periodic average curve. The differences are especially marked from the middle of April to the middle of May.

1935. The year's curve lies well below the average curve from the end of March till the middle of May and quite above it during the next two months.

(*b*) *Rainfall*

Year	The year's rainfall till					Date of occurrence of phenomenon
	April 30	May 31	June 15	June 30	July 7	
1941	3·91	8·81	..	..	..	10th June
1938	6·68	7·23	10·31	..	..	20th ,,
1943	7·88	9·72	12·45	..	..	20th ,,
1933	5·36	10·03	10·45	28·47	36·38	13th July
1935	7·52	7·52	7·66	8·56	18·57	13th ,,
Average for the period 1928–43	6·87	8·78	10·70	17·06	22·13	2nd ,,

(*c*) *Humidity*

1941. Relative humidity was on the whole lower than average values during April and considerably above the average values from the first week of May to the middle of June. The values during the five weeks preceding the appearance of first ripe fruit on the 10th June ranged between 13 and 39%.

1938. During the first two weeks of April the year's humidity curve is slightly above the average curve. It shows a sharp depression of about 10% during the next three weeks and is well above the average from the middle of May till the third week of June.

1933. With a single depression of about 4% during the third week of May, the year's curve lies above the average curve from first week of April to the second week of May.

1935. The year's relative humidity curve is remarkably higher than the average curve during April, falls below it in the second week of May and remains below the average values till the first week of July – the differences during June ranging between 16 and 33%.

1943. Humidity data are not available.

Conclusions

The above data for mean temperatures, rainfall and humidity do not indicate any obvious correlation between the date of fruit ripening in the case of Mangifera indica and the changes in the three climatic factors during the few months preceding fruit ripening.

(*xv*) *Appearance of first ripe fruit in Shorea robusta*

Average date of first ripe fruits = 158 (7th June).
Date of first ripe fruit in 1938 = 149 (29th May).
Do. do. 1941 = 150 (30th May).
Do. do. 1932 = 164 (12th June).
Do. do. 1939 = 169 (18th June).
(Average date of maximum flowering : 14th April).

(*a*) *Mean temperatures*

1938. The year's mean temperatures fluctuated round the average values during March and April. From the last week of April till the end of May the 1938 curve is consistently higher than the average curve by about 2°F.

1941. The year's temperature curve lies above the average curve from February till the first week of May, the differences during April and the first week of May ranging between 2° to 6°F. The temperatures fell steeply in the next week and were 3° to 5°F. below the average for a fortnight. They were again about 1°F. above the normal in the last week of May.

1932. Excepting for the first fortnight of May, the year's mean temperatures were considerably higher than the average values during the period March to June.

1939. Temperatures during March and April were very much lower than the average. Those for May are not known.

(*b*) *Rainfall*

Year	Total rainfall till					Date of occurrence of phenomenon
	April 30	May 15	May 31	June 7	June 15	
1938	6·68	7·03	7·23	..	..	29th May
1941	3·91	6·15	8·81	..	..	30th „
1932	1·69	1·69	1·99	1·99	1·99	12th June
1939	4·50	4·50	5·69	6·32	10·45	18th „
Average for the period 1928–43	6·87	7·56	8·78	9·48	10·70	7th „

(*c*) *Humidity*

1938. During the first two weeks of April the year's humidity curve is slightly above the average curve. It shows a sharp depression of about 10% during the next three weeks and is well above the average from the middle of May onwards.

1941. April humidity was on the whole lower than the periodic averages. It was remarkably higher than the average in May and the first fortnight of June, the difference in the last three weeks of May being as high as 13 to 19%.

1932. The year's values of relative humidity were 5 to 11% below the normal in the first fortnight of April and from 2 to 4% above the average in the second fortnight of the month. From the beginning of May till the appearance of first ripe fruit in the second week of June the year's humidity was very much below the average values – the differences from the second week of May onwards ranging between 6 to 27%.

1939. Excepting for the first week of May the year's relative humidity curve lay well below the periodic average curve from the third week of April to the first week of June, the differences during the last two weeks of April and from the third week of May to the first week of June ranging between 5 to 11% and 13 to 27% respectively.

Conclusions

It is not possible to offer a satisfactory explanation of the fluctuations in the date of first ripe fruit in sal on the basis of the changes in mean temperatures alone. The cumulative rainfall in May and early June was appreciably lower than normal in the years of late fruit ripening and almost normal in the years of early fruit ripening. Humidity during April and May was remarkably lower than the average in both the years of late fruit ripening. As opposed to this the curves for 1938 and 1941 rise sharply over the average curve during May. It thus appears that low values of cumulative rainfall during May and early June coupled with low relative humidity during the period mid-April to early June tend to delay fruit ripening, while high rainfall and high relative humidity in April and May advance the phenomenon. High temperatures also probably tend to advance fruit ripening, but their effect, as in 1932, may be masked by exceptionally dry weather.

10. Discussion

The above observations show that high mean temperatures coupled with low relative humidity and low winter rainfall probably advance the date of new leafing in *Albizzia procera* and *Dalbergia sissoo*; while low temperatures, high relative humidity and rainfall appear to have an opposite effect. In the case of *Cedrela toona* temperature and humidity alone are probably influential and the observed data do not suggest a consistent relation between rainfall and the beginning of foliar renewal. The phenomenon in the case of *Mangifera indica* and *Shorea robusta* appears to be independent of rainfall and humidity, while warmer temperatures in the few weeks preceding its occurrence are associated with its early commencement and lower temperatures with delays in commencement.

High temperatures are associated with early flowering of *Albizzia procera, Dalbergia sissoo, Mangifera indica* and *Shorea robusta* while low temperatures are associated with the delayed occurrence of the phenomenon. In the case of *Albizzia procera* rainfall lower or higher than the average appears to have similar effect as high or low temperatures respectively, while humidity does not appear to be of any consequence. Just the reverse is the case with *Dalbergia sissoo* where low and high values of relative humidity are associated with early and late beginning of flowering respectively, and rainfall appears to exercise no appreciable influence. Both rainfall and humidity appear to have no connection with the date of flowering in *Mangifera indica* and *Shorea robusta*. The observed data for *Cedrela toona* suggest that the time of flowering in this case is probably independent of variations in the three climatic factors.

As in the case of flowering in *Cedrela toona*, the date of first ripe fruit in *Dalbergia sissoo* and *Mangifera indica* does not appear to be materially influenced by the fluctuations in temperature, rainfall or humidity. Heavy rainfall from October of the previous year till April

appears to cause early fruit ripening in *Albizzia procera* while deficit rainfall in the period is associated with the late occurrence of the phenomenon. Temperature and humidity do not show any consistent relationship. In the case of *Cedrela toona* high temperatures appear to advance fruit ripening and low temperatures probably delay it. Variations in winter rainfall and humidity do not appear to exercise any influence on fruit ripening. The phenomenon in the case of *Shorea robusta* is delayed by low rainfall and relative humidity while high values of these factors are associated with its early occurrence. High temperatures also probably advance fruit ripening but their effect may be masked by exceptionally dry weather.

It thus appears that while fluctuations in dates of occurrence of the three phenomena under reference can in most of cases be correlated with parallel fluctuations in the main climatic factors, the measure and direction of influence of the later varies with the species and the phenomenon in question. As a rule a spell of warm weather in the short period preceding the normal date of occurrence of the phenomenon tends to advance new leafing and flowering. Low rainfall and relative humidity also exercise a similar influence, though the influence in some cases may not be marked. Low temperatures, high rainfall and humidity have an opposite effect. High temperatures appear to quicken fruit ripening in *C. toona* and probably *Shorea robusta* also. Heavy rainfall and high humidity also probably advance fruit ripening in certain cases (*Albizzia procera* and *Shorea robusta*). This is in contrast with the influence of these factors on new leafing and flowering where they appear to show an opposite tendency. Fruit ripening in *Dalbergia sissoo* and *Mangifera indica* does not show any clear relationship with temperature, rainfall or humidity.

11. Remarks about the Future Conduct of the Investigation

The necessity of adopting a definite policy about the period over which observations are to be made for each species is selfevident. Information based on a single or at the most a few years may not be reliable. Continuing the work on the same species for a very long period may also serve no useful purpose when the effort could be better utilized elsewhere. A period of 10 to 15 years appears to be adequate and would also cover the shorter 7 to 11 year's climatic cycles, supposed to exist in nature.

Detailed data regarding rainfall, temperature and humidity are being collected under a separate project. It would be advisable to collect information about other important factors such as soil moisture and temperature at different levels and the light conditions.

The existing field observations have been made by a number of subordinates. In a few cases the observer appears to have confused the phytophases and such unreliable data had to be rejected during the course of computation. It is imperative that the persons detailed for the job clearly understand what is required and are subjected to as few changes as possible.

12. Acknowledgements

This long term investigation was started as early as 1928 and numerous officers and staff of the branch have been reponsible for the collection of the voluminous data. Our grateful thanks go to them especially to Shri S. N. Dabral, B.Sc., Ranger, Forest Research Institute whose long participation with these studies was of great help to us in the preparation of this record. The actual analysis of the data and the preparation of the numerous diagrams were done in the Statistical Section of the Silviculture Branch. The botanical names were kindly verified by the Forest Botanist.

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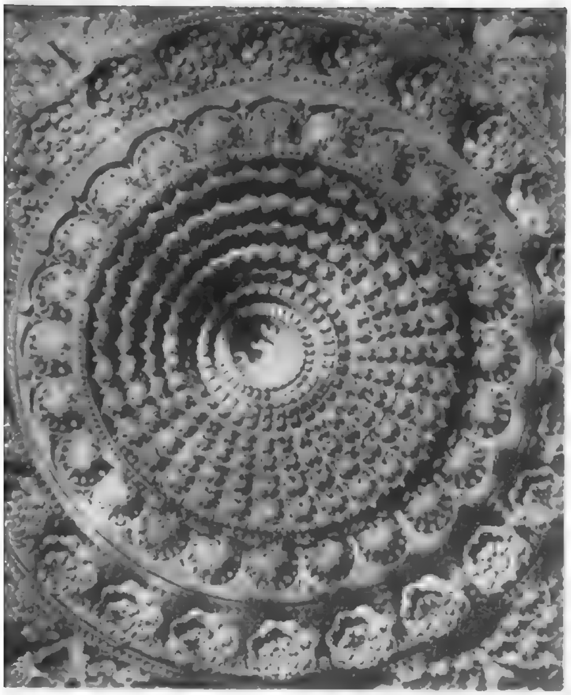

Marble ceiling Dilwara Temple, Mount Abu.
Photo by V. S. Krishnaswamy.

A near view of carving on a Marble pillar Dilwara Temple, Mount Abu.
Photo by V. S. Krishnaswamy.

One of the Tirthankars Dilwara Temple, Mount Abu.
Photo by V. S. Krishnaswamy.

Marble colonnade Dilwara Temple, Mount Abu.
Photo by C. R. Ranganathan.

A BOTANICAL VISIT TO MOUNT ABU

BY M. B. RAIZADA
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Mount Abu is situated in 24° 36′ North latitude and 72° 43′ East longitude, close to the south western extremity of the Aravalli Hills. Although regarded as a part of the Aravalli range, it is separated from that chain by a valley about 15 miles wide. The natural features of Abu are very bold as it rises suddenly from the flat plain like a rocky island lying off the sea coast of a continent. In shape it is long and narrow ; but the top spreads out into an irregular but picturesque plateau nearly 4,000 feet above the sea-level, about 14 miles in length and two to four miles in breadth. The base is about 20 miles in length by 8 miles in breadth at its widest part. The direction of the hill is from South-West to North-East. The highest peak, Guru Shikhar (Hermit's Pinnacle) towards the North end is 5,653 feet above sea-level.

Abu – a hill town whose streets, buildings, monuments and shrines are regarded with sentimental attachment by millions of people scattered throughout India – is a place of great sanctity. The Jains claim it for Adinath, the first of their Tirthankars, and the Hindus for Iswara ; the local deity is styled as Achaleshwar (the Immovable Lord). It appears from the inscription met with on the hill that Abu was originally a stronghold of Shaivism, and that the Jains whose magnificent temples at Dilwara are the crowning attraction of the hill, did not appear on the scene till about 1032. A century and a half after this, Jainism was in the ascendant, and numerous inscriptions record the erection of shrines or the gift of images between 1230 to 1320, but Shaivism then again got the upper hand and no more Jain Inscriptions are met with till the fifteenth century, whence they continue till 1752. Then Shaivism once again asserted itself.

The architectural wonders of Abu are no less interesting than its natural beauties. It possesses perhaps the most exquisitely carved Jain temples in the world, which are held in great esteem by lovers of art of all castes and creeds. Numerous tourists and travellers from Europe, America and other parts of the world visit these shrines every year and admire the elaborate and tasteful designs and the delicacy of workmanship. All these edifices are of white marble which must have been transported to the summit of the hill at great cost by some device of which we are now altogether ignorant. They date entirely to the 11th century and are free from subsequent additions of any consequence.

The hill is not far from the beaten track and is not difficult of access. Abu Road (on the metre-gauge main line of the Western Railway between Delhi and Ahmedabad) is 16 hours journey from Bombay and 19 hours from Delhi, but Abu Road is by no means Mount Abu. The town itself is perched high upon a hill that no railway has scaled and it needs a 1½ hours' climb up a zigzag tarred road on which bullock carts, motor cars and lorries ply regularly, before the traveller finds himself on the 'Lordly' Mount Abu. The half-way house or its equivalent is Chhipaberi Chowki, where there are a few enormous banyan trees which serve as a resting stage for pilgrims and whose picturesqueness increases the charm of the place.

The climate of Abu is very delightful during the hot months – particularly in the months of April, May and June. There is almost always a refreshing and generally cool breeze, and the traveller after performing the ascent experiences a most agreeable feeling of relief in escaping from the heat and dust of the plains.

The rains normally break at Abu about the 3rd week of June and go on till September. The rainfall is generally heavy, but not excessive, and varies from year to year. The average

during the last 10 years has been 70 inches, but there have been years of unusual rainfall, such as 1934, in which 100·80, and 1944 in which 158·13 inches were registered; again in 1936, 22·95, and in 1939, 19·76 inches only were recorded. This season is rendered somewhat unpleasant by the prevalence of fog and drizzle, but it is during and just after the rains that the place wears its most beautiful aspect, a break in the rains far from producing the enervating stickiness so unpleasantly familiar in the plains, leads here to delightful and invigorating weather amidst green hills and water-falls.

From October to the end of November, the weather is perfect, and it is perhaps at this period between the end of the monsoon and the coming of the real cold weather, that Abu has the greatest advantage over the plains. From December to the end of February the climate is healthy and bracing and fires are required. But although frosty nights are frequent, it is by no means unpleasantly cold.

The seasons do not differ in time from those usually experienced in the plains, except that the temperature is always 15 to 20 degrees lower. The highest temperature recorded in the past 10 years was 100°F. on 24th May, 1949 and the highest minimum temperature 88·3°F. on 23rd May, 1943. The lowest minimum temperature registered in the last 10 years was 31·6°F. on the 11th February, 1950. The mean temperature for May is about 80°F. with a drop of about 16° at night.

Abu is mainly composed of greyish large grained granite, which often contains distinct veins of quartz, trap, green stone, gneiss and schist. Fragments of mica and hard crystalline lime stone are met with in different parts of the mountain. Fine specimens of rock crystal are also occasionally found. The Abu granite is much used for building purposes.

There are two marble mines on the hill, one within the limits of Achalgarh, named Vansvalla and the other at Utraj—a village beyond Guru Shikhar. The Jain temples at Dilwara are, however, said to have been built with marble quarried from the mines at Jariwao in Rajasthan.

The beauty of Abu is much enhanced by the Nakhi Talao, or the lake, said to have been excavated by the 'finger-nails' (nakhi) of the gods. Tod described it as about 400 yards in length, while Fergusson knew no spot in India so exquisitely beautiful. The lake is now about half a mile long by a quarter of a mile broad, most picturesquely situated between high hills except at the western end, where a peep of the distant plains is obtained through a gorge. The slopes and ravines in the vicinity are well wooded, and several rocky islands add to the beauty and colour of the scene.

There are several curious and grotesquely shaped rocks. The rock on the southern side of the Nakki Lake which resembles an immense toad is known as the Toad Rock. The other striking looking rock which is known as the Nun Rock, and which resembles a veiled woman, is near the tennis courts of the Rajputana Club. It was struck by lightning in 1890, and the piece of stone representing the nose was detached.

Amongst the most interesting spots where natural grandeur can be seen at its best is Sunset Point. From the west of the Polo Pavilion goes a well-constructed road to the edge of the hill from where a picturesque view of the setting sun attracts many sight-seers. The camera cannot convey adequately the wonderful impression of the illimitable magnificence and immensity of the scene which one sees from this point in the evening.

The celebrated Dilwara temples (devalwara, 'the place of temples') are situated about a mile to the north of the station. They are five in number and all dedicated to Jainism; and two of them require special notice, being, in many respects, unrivalled in India. The first is the temple of Vimla Sah, built in 1032 A.D., as the inscriptions show. It is dedicated to Adinath, the first of the twenty-four Tirthankars of the Jains. The second, which is just opposite, is the temple of the two brothers Vastupala and Tejpala; it is dedicated to Neminath,

the twenty-second of the Tirthankars, and was built in 1231. Both are of white marble, and carved with all the delicacy and richness of ornament which the resources of Indian art at the time of their creation could devise. The temple of Vimla Sah consists of a shrine, containing a large brazen image of Adinath with jewelled eyes and wearing a necklace of brilliants. In front is a platform which, with the shrine, is raised three steps above the surrounding court. The platform and the greater part of the court are covered by a *mandap* or portico, cruciform in plan and supported by forty-eight pillars. The eight central pillars are so arranged as to form an octagon supporting a dome, which, together with its circular rims and richly carved pendant, forms the most striking and beautiful feature of the entire composition. The whole is enclosed in an oblong courtyard surrounded by fifty-two cells, each of which contains an image of one of the Tirthankars. Externally the temple is perfectly plain, and the visitor is totally unprepared for the splendour of the interior. At the entrance is the *hathi-khana* or elephant-room, in the doorway of which stands a life-size equestrian statue of Vimla Sah. Round the room are ten marble elephants which formerly bore riders, but the figures have nearly all been removed. In the other temple (that of Vastupala and Tejpala), the dome is the most striking feature. It stands on eight pillars and is a magnificent piece of work. It has a pendant which is a perfect gem.

Round the courtyard are thirty-nine cells containing one or more images, and some of the ceilings of the porches in front of these cells are elaborately carved. Like its neighbour, this temple has its elephant-room, which, however, is much larger, taking up one side of the court, and is enclosed by a pierced screen of open tracery. Inside the room are ten elephants, which, with their trappings, knotted ropes, &c., have been sculptured with exquisite care. As in the older building, the riders have disappeared, but the slabs behind the elephants tell us who they originally were : for example, Vastupala with his two wives, Lalita Devi and Wiruta Devi ; and Tejpala with his wife Anupama.

The shrine of Achaleshwar, the tutelary divinity of Abu, is about 5 miles from the civil station. In this temple the object of great sanctity is the toe of God Shiva which has attracted homage from countless generations of devotees. Below the emblem there is a hole of immeasurable depth into which no one is allowed to put his hand, and which we are told goes right to *patal* (innermost core of the earth). There is also a statue of Mera, the wife of Achaleshwar, which is very attractive to the eye and is the object of adoration. In front of the temple is a big brass bull (the Vehicle of Lord Shiva) bearing the marks of violence on his flanks. The tale runs that Md. Begra the king of Ahmedabad, injured it in search of treasure, but while he was leaving Abu, Shiva let loose a swarm of bees on the retreating force and they had to run away leaving their arms and ill-gotten booty.

Near the Achaleshwar Temple is a very big tank, 900 feet long and 240 feet broad, known as Mandakini Kund, the water of which is supposed to be as purifying as that of the Ganga. According to legend in the old days this tank was full of ghee. Three demons disguised as buffaloes used to steal ghee from the tank at night. Adipal Pramar killed these three animals simultaneously with one bolt. A statue of Adipal Pramar carrying a bow in his hand and 3 full size buffaloes stand close together at the edge of the tank. The tank and the famous statues of Adipal and the buffaloes are now all in ruins and present a spectacle of sad neglect.

Guru Shikhar (the Hermit's Pinnacle) is situated towards the northern end and is 5,653 feet above sea-level and 400 feet higher than any other peak on Abu. It is about 8 miles from Abu, and 3 miles from Oria. The top is crowned with a shrine to Dhuttashri, into the construction of which a conveniently weathered boulder has been incorporated. From the Oria Dak Bungalow this edifice appears like a gigantic statue of Buddha. Close to the statue are also the foot prints of Ramananda, the great Vaishnava preacher of the 14th century and a big bell suspended from a wooden frame with a Gujerati inscription dated the 1411 A.D.

Owing to its heavy rainfall, Abu is, as regards vegetation, by far the richest spot in the whole of Rajasthan. On the higher parts of the mountain, the vegetation is more or less of the humid tropical type. The most noteworthy species are : an epiphytic orchid, *Aerides crispum* Lindl. ? (*ambartari*) which clings to mango and other trees and in the rains produces fine racemes of delicate pink or lilac flowers ; the stinging nettle (*Girardinia heterophylla* Dcne.) white and pink wild roses, *Rosa moschata* and *R. involucrata* much used for hedges, and a beautiful sight when in full bloom, the *Karunda* (*Carissa opaca* Stapf), *Champa* (*Michelia champaca* Linn.) and several species of Jasmine, especially *Jasminum humile* Linn. which abounds on Guru Shikhar and a large blue flowered shrub, *Kara* (*Strobilanthes callosus* Nees), which blooms every seventh year or so about September. *Crataeva religiosa* Forst., with its creamy yellow flowers and delicately-tinted stamens, is common on the middle and lower slopes of the hills, while the prevailing tree on the slopes of Abu is the mango. It is doubtfully indigenous but is believed to have been introduced by the pilgrims who have for ages frequented the sacred shrines for which this mountain is famous. It is now, however, completely naturalized and is the commonest of the larger trees. In addition to the above, *Jaman* (*Syzygium cumini* Skeels) and *Bauhinia purpurea* Linn. are fairly common. The Karanj, *Pongamia pinnata* Pierre is found in several of the lower valleys and *Firmiana colorata* R. Br. is not uncommon. Of the introduced species mention must be made of chir pine (*Pinus roxburghii*) silky oak (*Grevillea robusta*), willows (*Salix* sp.) and Eucalyptus, all of which grow well here. Garden escapes are not uncommon. The beautiful potato creeper, *Solanum seaforthianum* And. and an orange-yellow cosmos-like plant, *Tithonia tagetifolia* Desf. are running wild and naturalized.

The most important formation at Mt. Abu is the *Euphorbia-anogeissus* consociation, probably due to environmental factors. It owes its origin to topographical succession. This formation contains, *inter alia*, a large proportion of *Phoenix sylvestris* trees even above 5,000 feet elevation, and this is probably the result of frequent fires. In the valleys, a rich flora of the moist deciduous type containing *Syzygium cumini*, *Dalbergia sissoo*, *Lannea grandis* prevails. In general, the flora of Mt. Abu seems to conform to the flora of the high elevation deciduous forests usually met with on the outer slopes of the Himalayas.

The following pages deal mainly with a collection of plants made by the writer during a short botanical visit to Mount Abu during September 1953. The list, which contains about 240 species, is by no means complete but it is hoped that on some future occasion it might be possible to fill in some of the gaps. The accompanying list contains the names of all the plants collected by the writer as well as those observed by him during the tour.

FILICALES

Actinopteris dichotoma Forsk.
Adiantum lunulatum Burm.
Athyrium falcatum Bedd.
Athyrium filix-femina (Linn.) Roth. ?
Botrychium virginianum Sw. ?
Cheilanthes farinosa Kaulf.
Ophioglossum sp.
Tectaria macrodonta (Fee) C. Chr.

CONIFERAE

Pinus roxburghii Sargent.
  Pinus longifolia Roxb.

MAGNOLIACEAE

Michelia champaca Linn. (Cultiv.).

ANNONACEAE

Miliusa tomentosa (Roxb.) Sinclair.
  Saccopetalum tomentosum (Roxb.) Hk. f. & Th.

MENISPERMACEAE

Cocculus hirsutus (Linn.) Diels.
  Cocculus villosus DC.

BERBERIDACEAE

Berberis asiatica Roxb.

FUMARIACEAE

Fumaria indica Pugsley.

CRUCIFERAE

Capsella bursa-pastoris Moench.
Cardamine hirsuta Linn.
Nasturtium indicum (Linn.) DC.

CAPPARIDACEAE

Capparis grandis Linn. f.
Capparis sepiaria Linn.
Crataeva religiosa Forst. f.

VIOLACEAE

Viola patrinii DC.

FLACOURTIACEAE

Flacourtia sepiaria Roxb. ?

POLYGALACEAE

Polygala persicariaefo ia DC.

CARYOPHYLLACEAE

Arenaria serpyllifolia Linn.
Polycarpon indicum (Retz.) Merrill.
  Polycarpon loefingiae Benth. & Hk. f.

MALVACEAE

Abelmoschus manihot (Linn.) Medik.
  Hibiscus tetraphyllus Roxb.
Hibiscus ficulneus Linn.
Sida veronicaefolia Lamk.

STERCULIACEAE

Firmiana colorata R. Br.
  Sterculia colorata Roxb.
Helicteres isora Linn.
Melhania futteyporensis Munro.
Sterculia urens Roxb.

TILIACEAE

Grewia tiliaefolia Vahl.
Triumfetta bartramia Linn.
  Triumfetta rhomboidea Jacq.

LINACEAE

Linum mysorense Heyne.

MALPIGHIACEAE

Hiptage benghalensis (Linn.) Kurz.
  Hiptage madablota Gaertn.

BALSAMINACEAE

Impatiens balsamine Linn.

RUTACEAE

Ruta graveolens Linn. (Cultiv.).

BURSERACEAE

Boswellia serrata Roxb.

MELIACEAE

Cedrela toona Roxb.

CELASTRACEAE

Celastrus paniculata Willd.

RHAMNACEAE

Zizyphus rugosa Lamk.

VITACEAE

Cayratia carnosa Gagnep.
  Vitis carnosa Wall.

ANACARDIACEAE

Lannea grandis (Dennst.) Engl.
Mangifera indica Linn.

PAPILIONACEAE

Aeschynomene indica Linn.
Atylosia sericeae Benth.
Butea monosperma (Lamk.) O. Kuntze.
  Butea frondosa Koenig.
Crotalaria albida Heyne.
Crotalaria linifolia Linn. f.
Crotalaria sericea Retz.
Dalbergia latifolia Roxb.
Dalbergia sissoo Roxb.

PAPILIONACEAE—(*concld.*)

Desmodium rotundifolium Baker.
Indigofera pulchella Roxb.
Lespedeza sericea Miq.
Melilotus indica All.
  Melilotus parviflora Desf.
Moghania bracteata (Roxb.) H. L. Li.
  Flemingia bracteata Wight.
Phaseolus mungo Linn. var. radiatus.
Pongamia pinnata (Linn.) Pierre.
  Pongamia glabra Vent.
Pueraria tuberosa (Roxb.) DC.
Shuteria involucrata W. & A.
Smithia bigemina Dalz.
Smithia capitata Dalz.
Smithia conferta Sm.
Vigna vexillata Benth.
Zornia diphylla Pers.

CAESALPINACEAE

Bauhinia purpurea Linn.
Caesalpinia sepiaria Roxb.
Cassia pumila Lamk.
Wagatea spicata Dalz.

MIMOSACEAE

Acacia arabica (Lamk.) Willd.
Albizzia lebbeck (Linn.) Benth.

ROSACEAE

Potentilla supina Linn.
Rosa involucrata Roxb.
Rosa moschata Mill.

COMBRETACEAE

Anogeissus sericea Brandis.

MYRTACEAE

Eucalyptus sp.
Syzygium cumini (Linn.) Skeels.
  Eugenia jambolana Lamk.

LYTHRACEAE

Woodfordia fruticosa (Linn.) Kurz.
  Woodfordia floribunda Salisb.

FICOIDEAE

Glinus lotoides Linn.
  Mollugo hirta Thunb.

SAMYDACEAE

Casearia tomentosa Roxb.

BEGONIACEAE

Begonia trichocarpa Dalz. ?

CUCURBITACEAE

Bryonopsis laciniosa (Linn.) Naud.
  Bryonia laciniosa Linn.
Cucumis melo Linn. var. agrestis Naud.

UMBELLIFERAE

Angelica glauca Edgew.
Carum stictocarpus Clarke.
Peucedanum dhana Ham. var. dalzellii Clarke.

RUBIACEAE

Borreria stricta (Linn.) Schum.
  Spermacoce hispida Linn.
Hamiltonia suaveolens Roxb.
Mitragyna parvifolia (Roxb.) Korth.
  Stephegyne parvifolia Korth.
Oldenlandia corymbosa Linn.

COMPOSITAE

Acanthospermum hispidum DC.
Ageratum conyzoides Linn.
Artemisia parviflora Roxb.
Blumea kingii Clarke ex Hk. f.
Centratherum phyllolaenum Benth.
Conyza stricta Willd.
Cyathocline purpurea (Don) O. Kuntze.
  Cyathocline lyrata Cass.
Eclipta alba (Linn.) Hassk.
Emilia sonchifolia (Linn.) DC.
Gnaphalium hypoleucum DC.
Gnaphalium indicum Linn.
Gnaphalium luteo-album Linn.
Helianthus annus Linn.
Lagascea mollis Cav.
Senecio grahamii Hk. f.
Sonchus arvensis Linn.
Sonchus asper Linn.
Tithonia tagetifolia Desf.
Tricholepis glaberrima DC.
Vicoa indica (Willd.) DC.
  Vicoa auriculata Cass.
Xanthium strumarium Linn.

CAMPANULACEAE

Campanula canescens Wall.

PLUMBAGINACEAE

Dyerophyton indicum (Gibs.) O. Ktze.
Vogelia indica Gibs.
Plumbago zeylanica Linn.

PRIMULACEAE

Anagallis arvensis Linn.

OLEACEAE

Jasminum grandiflorum Linn.
Jasminum humile Linn. ?
Jasminum pubescens Willd.

APOCYNACEAE

Beaumontia grandiflora (Roxb.) Wall. (Cultiv.).
Carissa sp.
Vallaris solanacea (Roth) O. Kuntze (Cultiv.).
Wrightia tinctoria R. Br.

ASCLEPIADACEAE

Ceropegia sp.
Cryptolepis buchanani R. & S.
Marsdenia volubilis (Linn. f.) Cooke.
Dragea volubilis Benth.

GENTIANACEAE

Canscora diffusa R. Br.
Limnanthemum cristatum Griesb.

BORAGINACEAE

Ehretia laevis Roxb.
Trichodesma indicum R. Br.

CONVOLVULACEAE

Convolvulus arvensis Linn.
Cuscuta reflexa Roxb.
Evolvulus alsinoides Linn.
Ipomaea nil (Linn.) Roth.
Ipomaea hederacea Auct. *non* Jacq.

SOLANACEAE

Datura fastuosa Linn.
Nicandra physaloides Gaertn.
Nicotiana plumbaginifolia Viv.
Solanum indicum Linn.
Solanum nigrum Linn.
Solanum seaforthianum T. And.

SCROPHULARIACEAE

Limnophila indica (Linn.) Druce.
Limnophila racemosa Benth.
Linderbergia indica (Linn.) O. Kuntze.
Linderbergia urticaefolia Lehm.
Verbascum coromandelianum (Vahl.) O. Kuntze.
Celsia coromandeliana Vahl.
Veronica anagallis Linn.

ACANTHACEAE

Adhatoda vasica Nees.
Asteracantha longifolia (Linn.) Nees.
Hygrophila spinosa Anders.
Barleria cristata Linn.
Barleria prionitis Linn.
Carvia callosa (Wall.) Bremek.
Strobilanthes callosus Nees.
Haplanthus verticillatus (Roxb.) Nees.
Justicia diffusa Willd.
Justicia simplex Don.
Lepidagathis cuspidata Nees.
Petalidium barlerioides Nees.

VERBENACEAE

Lantana camara var. aculeata Mold.
Lantana aculeata Linn.
Lantana indica Roxb.

LABIATAE

Anisochilus eriocephalus Benth.
Anisomeles indica (Linn.) O. Kuntze.
Anisomeles ovata R. Br.
Lavandula bipinnata var. rothiana O. Kuntze.
Lavandula burmanii Roth.
Leucas urticaefolia R. Br.
Nepeta hindostana (Roth) Haines.
Plectranthus mollis (Ait.) Spr.
Plectranthus incanus Link.
Plectranthus parviflorus Benth.
Plectranthus rugosus Wall.
Salvia leucantha Cav. (Cultiv.).
Salvia splendens Ker-Gawl. (Cultiv.).

AMARANTHACEAE

Alternanthera sessilis (Linn.) R. Br.
Alternanthera triandra Lamk.
Celosia argentea Linn.

POLYGONACEAE

Polygonum barbarum Linn.
Polygonum glabrum Willd.
Polygonum plebejum R. Br.
Rumex dentatus Linn.

PROTEACEAE

Grevillea robusta A. Cunn.

EUPHORBIACEAE

Euphorbia neriifolia Linn.
Euphorbia nivulia Buch.-Ham.
Euphorbia pycnostegia Boiss.
Kirganelia reticulata (Poir.) Baill.
Phyllanthus reticulatus Poir.
Mallotus philippensis Muell. Arg.
Mallotus philippinensis Auct. plur. per sphalm.
Securinegea leucopyrus (Willd.) Meull.
Flueggea leucopyrus Willd.

URTICACEAE

Artocarpus heterophyllus Lamk. (Cultiv.).
Artocarpus integrifolius Auct. *non* Linn. f.
Ficus benghalensis Linn.
Ficus glomerata Roxb.
Ficus religiosa Linn.
Ficus retusa Linn.
Girardinia heterophylla Decne.
Holoptelea integrifolia (Roxb.) Planch.
Pouzolzia indica Gaud.
Trema orientalis Bl.

SALICACEAE

Salix sp.

CERATOPHYLLACEAE

Ceratophyllum demersum Linn.

HYDROCHARITACEAE

Hydrilla verticillata (Linn. f.) Presl.

ORCHIDACEAE

Aerides crispum Lindl. ?
Eulophia ochreata Lindl.
Habenaria sp.

ZINGIBERACEAE

Curcuma sp.

AMARYLLIDACEAE

Furcraea gigantea Vent. ?

DIOSCOREACEAE

Dioscorea sativa Linn.

LILIACEAE

Chlorophytum tuberosum (Roxb.) Baker.

COMMELINACEAE

Commelina benghalensis Linn.
Commelina obliqua Buch.-Ham.

ARACEAE

Colocasia esculenta (Linn.) Schott. (Cultiv.).
Colocasia antiquorum Schott.
Remusatia vivipara Schott.
Sauromatum guttatum (Wall.) Schott.

PALMEAE

Phoenix sylvestris Roxb.

LEMNACEAE

Spirodela polyrrhiza Schleid. ?
Lemna polyrrhiza Linn.

CYPERACEAE

Bulbostylis capillaris Kunth.
Carex myosurus Nees.
Cyperus difformis Linn.
Cyperus exaltatus Retz.
Cyperus sanguinolentus Vahl.
Eriophorum comosum Wall. *ex* Nees.

GRAMINEAE

Apluda varia Hack.
Arthraxon lancifolius (Trin.) Hochst.
  Arthraxon microphyllus Hochst.
Arundinella pumila (Hochst.) Steud.
  Arundinella tenella Nees.
Brachiaria ramosa (Linn.) Stapf.
  Panicum ramosum Linn.
Capillipedium hugellii (Hack.) A. Camus.
  Andropogon schmidii Hk. f.
Cymbopogon martini (Roxb.) Wats.
  Andropogon schoenanthus (Linn.) Spr.
Cynodon dactylon (Linn.) Pers.
Dendrocalamus strictus Nees.
Desmostachya bipinnata Stapf.
  Eragrostis cynosuroides Spr.
Echinochloa colonum (Linn.) Link.
  Panicum colonum Linn.
Eragrostis nigra Nees & Steud.
Heteropogon contortus (Linn.) Beauv.
  Andropogon contortus Linn.
Isachne disper Trin.
Ischaemum impressum Hack.
Oplismenus compositus (Linn.) Beauv.
Panicum maximum Jacq. ?
Panicum paludosum Roxb.
  Panicum proliferum Hk. f.
Panicum psilopodium Trin.
Paspalum distichum Linn.
Pennisetum hohenackeri Hochst. *ex* Steud.
  Pennisetum alopecuros Steud.
Pennisetum typhoides Stapf & Hubb.
  Pennisetum typhoideum Rich.
Saccharum spontaneum Linn.
Sorghum halepense (Linn.) Pers.
  Andropogon halepensis Brot.
Spodipogon rhizophorus (Steud.) Pilger.
  Spodipogon albidus Benth.
Tripogon lisboae Stapf.

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INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART XIX.—WRITING AND PRINTING PAPERS FROM SUGARCANE BAGASSE

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SUMMARY

In India, bagasse (crushed sugarcane) is produced to the extent of over 1.5 million tons (on the bone-dry basis) in sugar mills. It is mostly used for burning in boilers for raising steam in the sugar mills themselves. This cellulosic material is used to some extent for the production of various kinds of papers in some parts of the world growing sugarcane. Intensive research work carried out in foreign countries prior to 1938 led to the conclusion that it is essential to remove pith from bagasse if this fibrous material is to be used for the manufacture of good quality writing and printing papers.

Processes used in foreign countries for the manufacture of pulp from bagasse require special patented machinery and licence of the inventors for their use by others. With a view to developing a process suitable to Indian conditions, an investigation was undertaken at this Institute on the separation of pith from bagasse and making writing and printing papers from the depithed material. Laboratory and pilot plant experiments gave encouraging results. A successful commercial run was carried out in Shree Gopal Paper Mills Ltd., Jamuna Nagar (Punjab), using 70% of bagasse pulp and 30% of bamboo pulp. This paper was used for printing a *dak* edition of *The Statesman*, New Delhi. Papers were also made on the pilot plant from mixtures of bagasse pulp with sabai grass and *ulla* grass (*Themeda arundinacea*) pulps and by adding bagasse pith to the bagasse pulp.

Samples of all these papers are appended in this bulletin. A sheet of the *The Statesman* printed on the bagasse-bamboo paper is also appended.

INTRODUCTION

The Pulp and Paper Consultation of the Food and Agriculture Organization of the United Nations, which met in Rome in December 1952, was of the opinion that the programme of increasing the availability of pulp and paper to under-developed countries could be well implemented through the use of those resources of the tropics capable of producing pulp and paper in so far as such use is technically and economically feasible[1]. In India, bamboo and sabai grass are mainly used at present for the manufacture of paper. With increase in literacy and industrialization, the demand for paper is bound to rise in this country in the next few years. Some of the existing paper mills are expanding their pre-war capacities and new mills have been established. In order to provide cheaper fibrous raw materials for use in the Indian paper industry to meet this increasing demand for paper, intensive research work on the production of papers from forest products and agricultural residues is being carried out at the Forest Research Institute. Sugarcane bagasse is one of such materials recently investigated.

Bagasse consists mainly of fibres and pith cells. The former forms about 65% and the latter about 35% of bagasse. The fibres are fine, strong and flexible and are suitable for the manufacture of papers of good quality. The pith, however, has no value as a paper-making material. Pulping of bagasse containing pith leads to a greater consumption of chemicals for cooking, difficulties in washing and bleaching of the pulp, decrease in the rate of drainage of the stock on the paper machine wire, and less opacity of the resultant papers.

A very interesting review of the utilization of bagasse for the manufacture of papers and boards of various kinds since 1838 is given by Joseph E. Atchison[2]. According to Atchison, all the commercial ventures prior to 1938 in the manufacture of saleable bagasse paper ended in failure except those which involved production of low quality paper, paperboard or wall-board. These failures were due to the use of bagasse without the removal of the pith. Research carried out in foreign countries prior to 1938 led to the conclusion that it was absolutely essential to separate a high percentage of pith from the bagasse if a high quality paper was to be produced from this raw material[2]. According to Atchison, this discovery is responsible for the successful establishment of bagasse pulp and paper mills in some parts of the world growing sugarcane.

The pilot plant of the Cellulose Development Corporation, England, was erected in 1939 for the production of high class pulp from bagasse among other fibrous raw materials. The pith is separated from bagasse in a special machine and the depithed bagasse is pulped by the Celdecor-Pomilio continuous soda-chlorine process. Taiwan Pulp Manufacturing Company, Tatu, Taichung (Formosa), belonging to Taiwan Pulp and Paper Corporation, and W. R. Grace & Company, Paramonga (Peru), started production of bagasse papers also in 1939. The Taiwan Pulp and Paper Corporation's Ensviko Pulp Co., Hsinying (Formosa), was established in 1940. The Formosa mills used the magnesium base acid sulphite process before World War II ; these two mills were put out of operation during the war. Since the war, the Hsinying mill has started working and is using the monosulphite process with a small concentration of caustic soda as a buffer. The Paramonga mill of W. R. Grace & Co., uses a modified soda process for the delignification of depithed bagasse[3]. The Sandy Hill Iron and Brass Works, U.S.A., has been authorized by W. R. Grace & Co., to manufacture the machinery needed for the Paramonga process and to license the system to others. In 1941, a bagasse pulp and paper mill went into production at Bais Central in the island of Oriental Negros in the Philippines. This mill uses the Celdecor-Pomilio process for the manufacture of bleached pulp and manufactures high class papers containing about 90% bagasse pulp. In 1951, Rohtas Industries Ltd., Dalmianagar (Bihar), started manufacturing bleached bagasse pulp by the Celdecor-Pomilio process, using the machinery supplied by the Cellulose Development Corporation, England.

Aschaffenburger Zellstoffwerke A. G., Redenfelden, Germany, is reported to have developed a process for the manufacture of various kinds of papers including newsprint grade from bagasse[4]. An interesting account of the recent work done in America on the production of newsprint grade paper from bagasse is given in the following :—

"Study of Newsprint Expansion. A Progress Report of the Department of Commerce to Sub-Committee No. 5 of the Committee on the Judiciary, House of Representatives, United States Government Printing Office, Washington, 1952".

The investigation described in this bulletin was undertaken with the object of developing a process for the removal of pith from bagasse without the use of patented machinery used by the bagasse mills mentioned earlier, of pulping the depithed bagasse using equipment generally used in the Indian paper industry, and of making various kinds of papers from bagasse.

AVAILABILITY OF BAGASSE

The sugarcane crushing season in India is from November to April. The quantity of bagasse that is produced in Indian sugar mills during the crushing season is given in Table I. These figures are worked out from the information supplied in 1952 by the Indian Sugar Mills Association, Calcutta. In calculating the bagasse available, the daily sugarcane crushing capacity of the mills in 1951 has been considered and the bagasse (on the oven-dry basis) is taken as 15% of the sugarcane crushed. The figures for bagasse given in column 4, Table I,

are calculated on the basis of 100 working (crushing) days per year and are given in round figures correct to only 500 tons. In Table I, the availability of bagasse is given area-wise and only those sugar mills are included which are considered to be suitable to supply bagasse for the manufacture of paper.

TABLE I

Annual availability of bagasse (based on the oven-dry basis)

Location	No. of Mills	Sugarcane Tons	Bagasse Tons	
South Bihar	4	4,55,000	68,000	68,000
North Bihar				
Darbhanga	5	4,67,000	70,000	
Muzaffarpur	2	2,07,000	31,000	
Champaran	9	8,50,200	1,27,500	
Saran	9	8,08,000	1,21,000	
				3,49,500
Eastern Uttar Pradesh				
Deoria	15	11,74,200	1,76,000	
Gorakhpur	6	5,76,200	86,500	
Basti	4	2,80,000	42,000	
Gonda	4	4,16,400	62,500	
				3,67,000
Western Uttar Pradesh				
Sitapur	3	4,37,500	65,500	
Hardoi	1	1,56,500	23,500	
Kheri	2	2,75,000	41,000	
Bareilly	2	2,18,200	32,500	
Pilibhit	2	3,08,000	46,000	
Bijnor	3	3,80,000	57,000	
Saharanpur	3	3,50,000	52,500	
Muzaffarnagar	4	4,78,000	71,500	
Meerut	7	6,16,600	92,500	
Moradabad	2	2,50,000	37,500	
Rampur	2	2,30,000	34,500	
				5,54,000
Punjab				
Ambala	1	1,00,000	15,000	15,000
Madras				
Nellikuppam	1	2,20,000	33,000	
Vuyyuru	1	85,000	13,000	
				46,000
Bombay				
Ahmednagar	7	4,60,000	69,000	69,000
P.E.P.S.U.	2	2,65,000	40,000	40,000
Mysore	1	1,40,000	21,000	21,000
Hyderabad	1	1,30,000	19,500	19,500
TOTAL	103			15,49,000

WRITING PAPER

made from 100% bagasse pulp (vide Serial No. 3, Table VIII)

PRINTING PAPER

made from a mixture of 80% bagasse pulp and 20% bamboo pulp

(vide Serial No. 4, Table VIII)

PRINTING PAPER

made from a mixture of 70% bagasse pulp and 30% sabai grass pulp
(vide Serial No. 5, Table VIII)

PRINTING PAPER.

made from a mixture of 70% bagasse pulp and 30% *ulla* grass pulp
(vide Serial No. 6, Table VIII)

PRINTING PAPER

made from 100% bagasse pulp (vide Serial No. 2*a*, Table VIII)

PRINTING PAPER

made from a mixture of 90% bagasse pulp and 10% bagasse pith
(vide Serial No. *2b*, Table VIII)

PRINTING PAPER

made from a mixture of 70% bagasse pulp and 30% bamboo pulp at Shree Gopal Paper Mills Ltd., Jamuna Nagar (vide Table IX)

(*The bagasse and bamboo pulps were made at the Cellulose and Paper Branch, Forest Research Institute, Dehra Dun*).

From the figures given in Table I it is clear that over 1·5 million tons of bagasse are produced every year in this country as a by-product of the sugar industry. Most of this bagasse is used by the sugar mills themselves for burning in boilers for generating steam. Unless the sugar mills are in a position to get an alternate fuel, they cannot part with their bagasse for paper manufacture.

PROXIMATE CHEMICAL ANALYSIS

Dry bagasse supplied by Belsund Sugar Co., Ltd., Riga (Bihar), was treated in the rod mill and then screened to remove the pith. The bagasse fibres thus obtained were used for the chemical analysis. Fresh bagasse containing about 45% moisture was received from Shri Janki Sugar Mills & Co., Doiwala (Uttar Pradesh). This was dried in the sun to about 10% moisture content and treated in a similar way in the rod mill and on the screen ; these separated bagasse fibres were also analysed.

The bagasse fibres from Riga and Doiwala were converted into dust using a hammer mill. The dust passing through 60-mesh and retained on 80-mesh was used in each case for the analysis employing the TAPPI standard methods. The results of the analysis are recorded in Table II.

TABLE II

		% on the oven-dry basis except moisture	
		Bagasse fibres from	
		Riga	*Doiwala*
1.	Moisture	6·87	4·11
2.	Ash	1·17	1·20
3.	Cold water solubility	2·41	9·65
4.	Hot water solubility	3·62	9·97
5.	1% NaOH solubility	33·06	33·35
6.	Ether solubility	0·39	1·47
7.	Alcohol-benzene solubility	1·52	7·84
8.	Pentosans	26·60	24·07
9.	Lignin	21·05	18·66
10.	Cellulose (Cross and Bevan)	54·86	58·65

From these results it is clear that the cellulose contents are high enough to warrant the utilization of bagasse fibres for paper-making. The lignin is also not very high. The high pentosan content suggests the suitability of these fibres for the production of grease-proof papers.

FIBRE DIMENSIONS

The depithed bagasse from Riga was pulped by the soda process using 18% caustic soda (on the basis of the oven-dry weight of the depithed material) in 30 g./litre concentration

at 153°C. for 6 hours. The pulp bleached with bleaching powder was used for the determination of the length and diameter of the fibres. The fibre dimensions are given in Table III. The fibre length distribution is given in Table IV and the fibre diameter distribution in Table V.

TABLE III

Fibre dimensions

	Fibre length	Fibre diameter
	mm.	mm.
Minimum	0·50	0·010
Maximum	3·75	0·033
Average	1·38	0·018

The ratio of average fibre length to diameter = 1 : 77.

TABLE IV

Fibre length distribution

Fibre length mm.	Number of fibres	% of fibres
0·50 to 1·00	26	13
1·01 to 1·50	68	34
1·51 to 2·00	56	28
2·01 to 2·50	26	13
2·51 to 3·00	8	4
3·01 to 3·50	10	5
3·51 to 3·80	6	3
TOTAL ..	200	100

TABLE V

Fibre diameter distribution

Fibre diameter mm.	Number of fibres	% of fibres
0·010 to 0·015	90	45
0·016 to 0·020	70	35
0·021 to 0·025	30	15
0·026 to 0·030	8	4
0·031 to 0·033	2	1
TOTAL ..	200	100

PRODUCTION OF PULP

Bagasse supplied by Jaswant Sugar Mills, Meerut (Uttar Pradesh), was used for the laboratory experiments. The moisture content of the bagasse was about 10%. Several experiments were carried out for effecting the separation of pith from the bagasse fibre. In the wet method, bagasse was taken in a disintegrator with a large quantity of water and after disintegration for some time, it was strained on a sieve. The pith passed through and the fibre remained on the sieve. In the dry method, kollergang and rod (roller) mill were tried for loosening the physical structure of bagasse. The bagasse so treated was screened on a screen of 12-mesh. Most of the pith passed through the screen. These experiments showed that better separation of the pith without much damage to the fibres from bagasse was possible when the rod mill was used ; in this case, about 65% bagasse fibres and 35% pith were obtained. Neither the fibre portion was entirely free from pith nor was the pith portion entirely free from the fibres. The depithed fibres obtained in this way were used for the pulping experiments. Several digestions were carried out by the soda process. In the first few experiments the cooking was carried out under relatively milder conditions using 10–15% caustic soda (on the basis of the oven-dry weight of the depithed bagasse) at 142°C. for 3 hours. Pulps containing shives were obtained. These were bleached with bleaching powder in two stages with an intermediate treatment with 2% caustic soda (on the basis of the oven-dry weight of the unbleached pulp). The colour of the bleached pulps was not satisfactory. *Hence, further experiments were carried out with* 16–20% caustic soda at 142°–162°C. for 6 hours. Well-cooked pulps were obtained, these could be easily bleached to a satisfactory whiteness. One digestion was carried out by the sulphate process. Some preliminary bleaching experiments (not reported here) were also carried out using elemental chlorine, caustic soda and bleaching powder. The digestion conditions, pulp yields, bleach consumption, strength properties and brightness of standard pulp sheets are recorded in Table VI. Photoelectric Reflection Meter Model 610 was used for determining the brightness of the pulp sheets.

PILOT PLANT TRIALS

For these trials, bagasse from two sources, viz., the Belsund Sugar Co., Ltd., Riga (Bihar) and the Shri Janki Sugar Mills & Co., Doiwala (Uttar Pradesh) was used. The bagasse containing about 10% moisture was treated in the rod mill and screened on a 12-mesh screen. The portion remaining on the screen was used for the digestions.

The digestions were carried out in a vertical stationary mild steel digester of the indirect heating – forced circulation type. The capacity of the digester was 100 cubic feet. After the cooking was over, the pulp was washed three times in the digester and then transferred to the potcher (capacity, 350 lb. pulp at 5% consistency) where it was thoroughly washed. Bleaching was carried out in the potcher in two stages. In the first stage, about 75% of the total bleaching powder required for the full bleach was used and the bleaching was carried out at 35°C. The partially bleached pulp was washed and treated at 70°C. for 1 hour with 2% caustic soda (on the basis of the oven-dry weight of the unbleached pulp). The pulp was again washed and treated with the remaining quantity of the bleaching powder. After washing, it was beaten in the beater (capacity, 350 lb. pulp at 5% consistency). The pulp could be beaten to about 150 c.c. (C.S.F.) freeness in about 2–2½ hours as against about 5 hours required for the bamboo pulps. The requisite quantities of rosin size, alum, china clay and/or titanium dioxide, and ultramarine blue were added and the stock was transferred to the machine chest. Writing and printing papers were made on the Fourdrinier machine (34″ deckle) of the pilot plant of the Institute at its maximum speed of 50 feet per minute.

In order to improve the opacity of the paper and bring down the cost of production, 10% pith was blended with 90% bagasse chemical pulp and printing paper was made. For

this, the pith separated from the bagasse fibres was screened on a 80-mesh sieve and koller-ganged at 10% consistency. The pith so treated was diluted with water and strained through a fine muslin and used for blending with bagasse pulp.

Since the fibre length of bagasse is only about 1·38 mm., it was thought desirable to blend bagasse pulp with a long-fibred pulp in order to get papers of better strength properties and to make the running of the papers smooth on a commercial machine. Therefore, printing papers were made from mixtures of bagasse pulp with bamboo, sabai grass (*Eulaliopsis binata*) and *ulla* grass (*Themeda arundinacea*)[5] pulps. The bamboo pulp was prepared by digesting bamboo (*Dendrocalamus strictus*) by the "Overhead" sulphate process using 22% of chemicals ($NaOH : Na_2S = 2 : 1$) (on the oven-dry basis of the raw material) in 55 g./litre concentration at 162°C. for 6 hours. The pulp was bleached with bleaching powder in two stages using an intermediate alkali treatment. This treatment was carried out with 2% caustic soda (on the weight of the unbleached pulp) at 70°C. for 1 hour.

The sabai grass was cut into small length and digested by the soda process using 17% caustic soda (on the basis of the oven-dry grass) in 34 g./litre concentration at 153°C. for 5 hours. The pulp was bleached with bleaching powder in two stages without the intermediate alkali treatment.

The *ulla* grass pulp was obtained by digesting by the soda process the crushed and chopped grass. The cooking was carried out with 17% caustic soda (on the basis of the air-dry grass) in 28 g./litre concentration at 153°C. for 6 hours. The pulp was bleached like sabai grass pulp.

The digestion conditions, pulp yields and bleach consumption are recorded in Table VII and the strength properties of papers in Table VIII. Samples of papers as stated in the last column of Table VIII are appended in this bulletin.

COMMERCIAL SCALE TRIAL

In order to study the performance of the bagasse pulp on a commercial Fourdrinier machine, a trial was carried out in the Shree Gopal Paper Mills, Ltd., Jamuna Nagar (Punjab). The bleached pulp (2,300 lb.) was made on the pilot plant of this Institute from the bagasse from Doiwala. For blending with bagasse pulp, bamboo pulp (1,000 lb.) prepared in this Institute was also taken to the Shree Gopal Paper Mills. Both the pulps were taken to Jamuna Nagar in the form of dry sheets.

Bamboo pulp (500 lb.) was first beaten in one of the Thornson beaters of the firm for nearly one hour when it had a freeness of 350 c.c. (C.S.F.). Rosin size (8 lb.), alum (30 lb.), china clay (20 lb.), titanium dioxide (15 lb.) and little quantities of Rhodamine and Methylene Blue (for blueing) were added and the beater was discharged into the machine chest. To this very beater was next added the bagasse pulp (1,150 lb.). It took nearly 45 minutes to load this pulp. The beater roll was applied gently after loading and the beating was continued for nearly 30 minutes when the freeness was 175 c.c. (C.S.F.). Rosin size (16 lb.), alum (90 lb.), china clay (60 lb.), titanium dioxide (35 lb.) and Rhodamine and Methylene Blue were added, and the beater was discharged into the same machine chest where the bamboo stock was previously transferred. The two stocks were mixed well in the machine chest. The freeness of the mixture of the two stocks was 203 c.c. (C.S.F.).

Another charge of bamboo and bagasse stocks was prepared in the same way in another Thornson beater. These stocks also contained the same quantities of the size, alum, etc., as in the previous case. Mixing of these two stocks was carried out in another machine chest.

The stock from the machine chests was taken to the breast box of the paper machine through the Jordan Refiner, sand-table, vortraps and Birdscreen. The freeness of the stock

at the breast box was 80 c.c. (C.S.F.) and the pH was 5·2. The Fourdrinier paper machine was run at 312 feet per minute. The paper machine had a plain wire of 72-mesh and the deckle was 118 inches. Two calender stacks each with 4 rolls were used for giving the necessary finish.

A quantity of 2,544 lb. of printing paper was obtained. Dry broke amounted to 490 lb. The balance (266 lb.) of the stuff was lost as wet broke. The strength properties of the printing paper are given in Table IX. A sample of the paper is appended in this bulletin.

The report given by the mill authorities about this trial says: "No trouble was experienced in running the stock on the paper machine. Some trouble was, however, experienced on the dry-end during the first half hour for adjustment of operation of the Calenders to give the necessary finish. Later on, the Machine ran smooth and steady without any abnormal breakage of paper."

The white printing paper made in this way had a pleasing appearance.

PRINTING OF "THE STATESMAN"

In order to ascertain whether a printing paper made from mainly bagasse could be used as newsprint, the paper made from 70% bagasse chemical pulp and 30% bamboo chemical pulp on the Fourdrinier machine of the Shree Gopal Paper Mills, Ltd., was tested on the rotary machine of *The Statesman*. An entire *dak* edition of *The Statesman* dated July 22, 1953, was printed on the bagasse paper. The rotary press was run at over 25,000 copies per hour, the web travelling at approximately 850 feet/minute. According to the Production Engineer of *The Statesman* Ltd., New Delhi, no trouble need be feared at even higher speeds.

A news item dated July 21, 1953 from the Special Representative of *The Statesman* which appeared in the July 22, 1953 issue of this newspaper (Delhi edition) said:

> "For the first time in India, newsprint prepared from sugarcane bagasse was used to-day by *The Statesman* in publishing an entire *dak* edition. The trial was declared a success. The paper took ink well and withstood the strain of the rotary. The only adverse comment which the printers passed was: 'It should be a little less translucent'. Considering that the paper was not really produced to serve as newsprint, this defect, it was stated, could be removed".

A sheet of the *dak* edition of *The Statesman* printed on the bagasse paper is appended in this bulletin.

DISCUSSION

The results of the laboratory experiments recorded in Table VI indicate that digestion of bagasse with lower quantities (10–12%) of alkali at 142°C. for a short period of 3 hours yields under-cooked pulps which cannot be bleached to a good whiteness with a reasonable quantity of bleaching powder. The 14% caustic soda pulp (bleached) was yellower than the 10% caustic soda pulp (Serial No. 3) because less bleach was used in the former case. The bleached pulps of Serial Nos. 2 and 4 (Table VI) are, however, suitable for cheap grade paper where a slight yellow tinge is of not much consequence. With 15% chemicals at 142°C., no special advantage was found in the sulphate process in comparison with the soda process.

The pulps obtained from cooks carried out with 18% caustic soda at 153°C. were satisfactory for the production of good quality writing and printing papers. The pulps from 16% caustic soda cooks took longer time to bleach than the 18% caustic soda cooks.

When the intermediate alkali treatment was given during bleaching, the whiteness of the pulp was better and the bleach consumption was slightly less, but there was a slight decrease in the yield of the bleached pulp. Estimation of the alpha cellulose of the pulps bleached with and without the intermediate alkali treatment showed that the alpha cellulose of the former pulp was higher (80·2%) than that of the latter (78·0%).

Bleached bamboo pulp usually takes about 45 minutes in the Lampen Mill to attain a freeness of 300 c.c. (C.S.F.); but bleached pulps from depithed bagasse can be beaten to 300 c.c. (C.S.F.) freeness in about 25 minutes.

The results of the pilot plant trials recorded in Table VII show that bleached pulp in 50–54·7% yield can be obtained by cooking depithed bagasse with 18% caustic soda at 153°–162°C. for 4–6 hours.

It is clear from the results recorded in Table VIII that writing and printing papers of satisfactory strength properties can be made from a mixture of bagasse pulp with bamboo, sabai grass or *ulla* grass pulp. Although papers have actually been made from 100% bagasse pulp on the Fourdrinier of the pilot plant, it will be necessary to add 10–30% of a long-fibred pulp, such as bamboo or sabai grass pulp, because the maximum speed of the pilot plant paper machine is only 50 feet/minute whereas paper machines in Indian paper mills are run at 280–300 feet per minute. The printing paper (Serial No. 2*b*, Table VIII) made from 90% bagasse pulp and 10% bagasse pith appears on visual examination to have higher opacity than that made from 100% bagasse pulp; the colour of the paper is yellowish and it has slightly lower strength properties. This paper seems to be suitable as a cheap grade printing paper.

The commercial scale trial described earlier showed that it was possible to produce good quality printing paper from 70% bagasse chemical pulp and 30% bamboo chemical pulp. It should be possible to reduce the percentage of the long-fibred pulp on a modern paper machine equipped with suitable controls.

The printing of the *dak* edition of *The Statesman* on the bagasse paper made at the Shree Gopal Paper Mills indicated that the paper was suitable for use as newsprint from the technical point of view, the only defect being a slight lack of opacity. It should be possible to remedy this defect by adding more china clay to the stock. The addition of pith to the furnish should help not only in improving the opacity but also in reducing the price of the paper. Papers made from bagasse chemical pulps must be expected to be more expensive than those made from groundwood pulps in the preparation of which no chemicals are used. The economics of the use of bagasse paper as newsprint are discussed elsewhere[6].

Bagasse Papers Versus Bamboo Papers – Economics

As mentioned earlier, bagasse is a waste by-product of the sugar industry and, in the absence of a better way of disposal, is used at present for burning in boilers for generating steam. Bagasse, as it comes out of sugarcane crushers, contains about 50% moisture. Three tons of such moist bagasse are equivalent to 1 ton of coal in fuel value. The price of bagasse will, therefore, depend upon the price of coal that can be made available to sugar mills. If the price of coal is taken as Rs. 36 per ton, the price of bagasse (on the oven-dry basis) works out to Rs. 24 per ton. The price of coal is less near collieries because of less transportation charges and, therefore, bagasse should be available at lower than Rs. 24 per ton in sugar mills situated near coal mines. Bagasse is produced only during the sugarcane crushing season (4–6 months) whereas paper has to be manufactured throughout the year. Therefore, bagasse requires to be baled and stored. Taking Rs. 6 as the baling charges per ton of bagasse, the price of this raw material (oven-dry basis) for paper manufacture at a sugar mill site should not be more than Rs. 30 per ton.

The minimum economic unit for the manufacture of writing and printing papers in this country may be taken to be one that has an annual capacity of 9,000 tons of paper. As a rough estimate it can be said that the cost of production of 1 ton of good quality paper from 100% bagasse will be Rs. 714 in a mill producing 9,000 tons of paper a year. This estimate is based on the price of bagasse at Rs. 30 per ton and a capital investment of Rs. 1·8 crores – Rs. 1·5 crores for machinery and Rs. 30 lacs for buildings. The depreciation on machinery is taken at 7% and on buildings at 5%. An estimate worked out on a similar basis shows that the cost of production of writing and printing papers from 100% bamboo is Rs. 924 per ton. Details of the two cost statements are given elsewhere[6]. Calculated on a similar basis, the cost of production of papers from 70% bagasse pulp and 30% bamboo pulp works out to Rs. 783 per ton.

From the figures given above, it can be concluded that a net annual saving of Rs. 12,69,000 will result, if 70% bagasse pulp is used in paper manufacture instead of 100% bamboo pulp, in the case of a mill producing 9,000 tons of paper per year.

Work is in progress on the production of writing and printing papers from bagasse at still cheaper price.

BAGASSE FOR PAPER MANUFACTURE – ADVANTAGES

There are several advantages in utilizing bagasse for the manufacture of writing and printing papers. As mentioned earlier, bagasse is a waste by-product of the sugar industry and has not yet been put to any productive use. It is a good fibrous raw material for paper manufacture after the removal of the pith. It is available in large quantities on a sustained yield basis. A portion of the total quantity available is sufficient for the manufacture of a large quantity of paper to meet the increasing demand for this commodity. About 2·8 tons of bagasse (on the oven-dry basis and with the pith) are required for making 1 ton of white paper using 100% bagasse pulp. The bagasse fibres can be pulped under milder conditions than bamboo which forms about 60% of fibrous raw materials used at present in the Indian paper industry. Pulping of bagasse requires less chemicals than bamboo. Good quality writing and printing papers can be manufactured at a cheaper price from bagasse than from bamboo or sabai grass.

SITE FOR BAGASSE PAPER MILLS

For the economic use of bagasse for paper manufacture, paper mills should be established as near sugar mills as possible. There are several sugar mills in this country which have a daily crushing capacity of about 1,200–2,000 tons of sugarcane. A paper mill established in the vicinity of about 3 such sugar mills will be able to get enough bagasse for the manufacture of over 75 tons of paper per day.

As mentioned earlier, sugarcane is crushed only for 4–6 months in a year. Bagasse, therefore, requires to be baled and stored under a roof for use for paper manufacture during the remaining period of the year. This requires large space and the site chosen for the establishment of paper mills should be satisfactory in this respect.

Bagasse is an economical material wherever supplies of coal are available at a cost not exceeding about Rs. 36 per ton, but obviously, the cheaper the coal, the cheaper would bagasse be.

Since bagasse fibres are of medium length, it is necessary to mix bagasse pulp with some long-fibred pulp such as bamboo pulp or sabai grass pulp. In this connection, it may be mentioned that Shree Gopal Paper Mills, Ltd., have started manufacturing since December

1953 about 100 tons of bagasse pulp per month by the process described in this bulletin. The pulp is used by them for admixing with sabai grass pulp in the production of writing and printing papers[7]. The availability of bamboo, sabai grass or some other long-fibred fibrous raw material should be taken into account while choosing sites for bagasse paper mills. If such raw materials are not available near otherwise suitable sites, pulps made from them elsewhere should be available at an economic price.

Other factors to be considered in choosing a suitable site include the availability of water and transport facilities. About 80,000 gallons of water are required for manufacturing 1 ton of writing and printing papers. If hydroelectric power is not available, pass-out steam turbines may be used for generating electric power. For the production of 1 ton of paper from fibrous raw materials, about 1,500 KWH energy is required.

OTHER PRODUCTS FROM BAGASSE

Some experiments were also carried out on the preparation of grease-proof papers from bagasse. Bagasse without removal of pith was used. Digestions were carried out by the neutral sulphite semi-chemical process using sodium sulphite (9–15%) and sodium carbonate (4–7%) at 153°C. for 3 hours. The pulp was bleached by the multistage bleaching process using elemental chlorine, caustic soda extraction and bleaching powder. The yields of the unbleached and bleached pulps were 55–62% and 50–53% respectively and the total bleach consumption (in terms of standard bleaching powder containing 35% available chlorine) was 7–11%. The pulps were white and had satisfactory strength properties. Some pulps were examined for grease resistance by the TAPPI Standard T 454 m–44 using turpentine tinted with a dyestuff. There was no turpentine transudation on the other side of the pulp sheet even after 1800 seconds. The 'Blistering Test'[8] also gave satisfactory results. After carrying out more experiments to confirm these results, the details will be published.

In order to find a suitable use for the pith separated from the bagasse in the preparation of good quality writing and printing papers, preliminary experiments were carried out on the preparation of insulation boards from this pith. Pith (4 lb.) was soaked in water overnight and steamed in the laboratory Asplund Defibrator with steam at 110 lb./sq. in. for 5 minutes. This was followed by defibration for 10 minutes. The pulp was washed and taken on the mould. After drainage of the water, the wet "mat" of the pulp was pressed in the hydraulic press at about 400 lb./sq. in. pressure to squeeze out water. This was followed by drying in the same hydraulic press at 130°C. under 50 lb./sq. in. pressure for 2 hours. The weight of the board ($17\frac{1}{2}'' \times 21\frac{1}{2}''$) was 2 lb. $9\frac{1}{2}$ oz. The thickness of the board was 0·41 inch. The equipment used for making the insulation board from the pith has been described in an earlier publication[9].

This board was tested for its thermal conductivity in the Composite Wood Branch of this Institute. Its thermal conductivity was reported to be 0·0654 K cal/mh°C. at a mean temperature of 21·54°C. The moisture content of the board under test was 8·27%. In terms of the British system, the thermal conductivity of this board is 0·527 B.T.U. per hour, per sq. foot, and °F. per inch thickness at a mean temperature of 70·79°F. In this connection, it may be noted that according to the American Commercial Standard (CS 42 — 35), the maximum thermal conductivity permissible for fibre insulating boards is given as 0·36 B.T.U. per hour, per square foot, and °F. per inch thickness at a mean temperature of 75°F. and oven-dry condition.

Two more insulation boards were made from pith under different conditions but their thermal conductivity values were higher. More experiments will be undertaken to improve the heat insulating properties of pith boards.

Conclusions

1. A satisfactory separation of the bagasse fibres from pith can be effected by the use of the rod mill and a suitable screen. This method gives about 65% fibres and 35% pith.

2. Bleached chemical pulps in 50–54·7% yield can be prepared from the depithed bagasse by the soda process followed by bleaching with bleaching powder.

3. Pilot plant and commercial scale trials have shown that good quality writing and printing papers can be produced from a mixture of bagasse pulp and bamboo or sabai grass pulp.

4. Writing and printing papers made from a blend of bagasse and bamboo pulps are cheaper than those made from only bamboo pulp.

5. The printing trials of *The Statesman* indicated that the printing paper from a mixture of 70% bagasse pulp and 30% bamboo pulp could be used as newsprint. The opacity of the paper used for the trial required to be still further improved. The price of this bagasse paper made from chemical pulps is, however, more than that of the imported newsprint made mainly from groundwood pulp.

6. Printing papers of cheap quality can be made by adding bagasse pith treated in a suitable way to a blend of bagasse and bamboo pulps.

7. Experiments carried out on the preparation of grease-proof pulps from the whole bagasse and of insulation boards from bagasse pith have given encouraging results.

Thanks are given to the Belsund Sugar Co. Ltd., Riga (Bihar) and the Jaswant Sugar Mills, Meerut (Uttar Pradesh), for the supply of bagasse free of cost. Thanks are also due to the Indian Sugar Mills Association, Calcutta, for supplying information regarding the availability of bagasse in India, to the Shree Gopal Paper Mills Ltd., Jamuna Nagar (Punjab), for carrying out the commercial trial, to *The Statesman* Ltd., New Delhi, for the printing trial, and to the Chief Research Officer, Composite Wood Branch of this Institute, for determining the thermal conductivity of the insulation boards from the pith.

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TABLE VI.—*Soda and sulphate digestions of depithed*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals*	Material liquor ratio	Digestion temperature	Digestion period†	Consump-*tion of* chemicals*	Unbleached pulp yield*	Bleach consumption *as standard* bleaching powder*	Bleached pulp yield*‡
	%		°C.	hours	%	%	%	%
1	10	1 : 6	142	3	10	65·0	9·8	55·0
2	10	1 : 6	142	3	10	65·0	12·9	54·2
3	10	1 : 6	142	3	10	65·0	15·0	54·0
4	12	1 : 6	142	3	12	61·0	5·8	53·1
5	14	1 : 6	142	3	14	60·0	4·1	51·2
6*a*	16	1 : 6	142	6	14·8	60·2	5·0	57·1
6*b*	16	1 : 6	142	6	14·8	60·2	5·3	57·9
7*a*	16	1 : 6	153	6	15·3	58·8	5·5	56·3
7*b*	16	1 : 6	153	6	15·3	58·8	5·9	57·5
8*a*	16	1 : 6	162	6	14·9	58·0	6·8	51·8
8*b*	16	1 : 6	162	6	14·9	58·0	7·1	53·9
9	18	1 : 6	142	6	15·6	57·5	4·6	53·3
10	18	1 : 6	153	6	16·4	55·5	4·8	51·0
11	18	1 : 6	162	6	17·1	55·0	6·2	50·2

bagasse and strength properties of standard pulp sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 72°F.

10	11	12	13	14	15	16	17	18
Freeness of pulp	Basis weight	Breaking length (Schopper)	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding endurance	Brightness	REMARKS
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds		
180	60·0	8900	4·9	84·0	47·0	1140	34	Shives were present and the colour of the bleached pulp was yellow. In Serial Nos. 1-5, intermediate alkali treatment was given during bleaching.
180	55·2	8300	4·9	72·0	46·0	780	50	Shives were present. The colour of the bleached pulp was nearly white.
320	57·4	7800	4·7	80·0	46·0	570	53	Do.
260	60·0	7500	5·3	88·0	51·0	790	39	Shives were present. The bleached pulp was yellowish.
305	57·4	7300	5·0	94·0	50·0	570	39	Do.
270	58·4	8890	4·4	65·9	51·3	370	63	Well-cooked pulp was obtained. The intermediate alkali treatment was given during bleaching.
300	57·6	8800	4·0	62·2	52·0	290	61	Same pulp as in Serial No. 6*a*. In this case no intermediate alkali treatment was given during bleaching.
299	58·8	8170	4·0	62·1	51·1	380	60	Well-cooked pulp was obtained. Intermediate alkali treatment during bleaching.
294	61·2	8610	4·2	62·6	51·9	460	57	Same pulp as in Serial No. 7*a*. No alkali treatment during bleaching.
318	61·2	7460	4·4	58·8	48·1	190	61	Well-cooked pulp was obtained. Alkali treatment during bleaching.
312	58·4	7790	4·3	62·1	49·8	300	57	Same pulp as in Serial No. 8*a*. No alkali treatment during bleaching.
300	60·0	8580	4·7	65·9	52·3	420	59	Well-cooked pulp was obtained. In Serial Nos. 9–11 alkali treatment was given during bleaching.
310	62·4	7590	4·4	64·9	47·4	180	66	Well-cooked pulp.
270	62·9	7400	4·4	59·1	44·3	140	63	Do.

(contd.)

TABLE VI.—*Soda and sulphate digestions of depithed*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals*	Material liquor ratio	Digestion temperature	Digestion period†	Consumption of chemicals*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder*	Bleached pulp yield*‡
	%		°C.	hours	%	%	%	%
12a	20	1 : 6	142	6	16·6	57·5	4·0	52·5
12b	20	1 : 6	142	6	16·6	57·5	4·2	53·8
13a	20	1 : 6	153	6	18·4	55·0	4·0	50·5
13b	20	1 : 6	153	6	18·4	55·0	4·2	53·3
14a	20	1 : 6	162	6	18·9	55·0	4·5	50·0
14b	20	1 : 6	162	6	18·9	55·0	4·7	51·7
15	15	1 : 6	142	3	..	57·5	4·6	53·8
16	15	1 : 6	142	3	..	57·5	5·1	50·5

* The % is expressed on the basis of the depithed bagasse (oven-dry).

† The digestion period recorded in the Table is the time taken by the contents of the digester to rise to the cooking temperature from 100°C. It took about ½ hour for the temperature to rise to 100°C. from the room temperature.

‡ In the case of pulps containing shives, the yield of the bleached pulp recorded here was determined after the removal of the shives.

bagasse and strength properties of standard pulp sheets—(concld.)

Strength Properties of Standard Sheets Conditioned at 65% R.H. and 72°F.								
10	11	12	13	14	15	16	17	18
Freeness of pulp	Basis weight	Breaking length (Schopper)	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding endurance	Bright-ness	REMARKS
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds		
310	58·4	8580	4·3	66·4	51·9	340	62	Well-cooked pulp. Alkali treatment during bleaching.
340	59·2	8110	4·2	71·8	51·8	410	59	Same pulp as in Serial No. 12*a*. No alkali treatment during bleaching.
310	60·4	8120	3·9	70·1	51·7	240	59	Well-cooked pulp. Alkali treatment during bleaching.
310	62·4	8120	3·9	70·2	48·1	240	59	Same pulp as in Serial No. 13*a*. No alkali treatment during bleaching.
320	60·8	7350	3·7	59·2	43·4	100	63	Well-cooked pulp. Alkali treatment during bleaching.
310	58·0	7240	3·8	59·1	43·0	130	60	Same pulp as in Serial No. 14*a*. No alkali treatment during bleaching.
295	60·8	8235	4·2	72·7	48·5	590	55	Shives were present. Alkali treatment during bleaching. Colour nearly white.
270	59·2	8210	4·6	71·8	48·7	700	58	Sulphate process (NaOH : Na_2S = 2 : 1) was used. Shives were present. Alkali treatment was given during bleaching. Colour nearly white.

TABLE VII.—PILOT PLANT TRIALS

Soda digestions of depithed bagasse and pulp yields

1	2	3	4	5	6	7	8	9	10
Serial No.	Total chemicals*	Material liquor ratio	Digestion temperature	Digestion period	Consumption of chemicals*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder*	Bleached pulp yield*	REMARKS
	%		°C.	hours	%	%	%	%	
1	18	1 : 6	153	4	16·6	54·5	3·7	50·0	Bagasse from Riga was used. A few shives were present. Intermediate alkali treatment was given during bleaching. This bleached pulp was used for making printing paper without blending with any other pulp.
2	18	1 : 6	153	6	17·4	54·2	5·2	..	Bagasse from Riga was used. Well-cooked pulp. Intermediate alkali treatment was given during bleaching. A portion of this bleached pulp was used for blending with pith for making a cheap grade printing paper.
3	18	1 : 6	162	6	17·5	..	5·3	52·7	Bagasse from Doiwala was used. Well-cooked pulp. No intermediate alkali treatment during bleaching.
4	18	1 : 6	153	4	15·7	..	4·4	54·7	Bagasse from Doiwala was used. A few shives were present. No alkali treatment during bleaching. This bleached pulp was used for blending with bamboo pulp for making printing paper.

5	18	1 : 6	153	6	16·2	..	4·6	53·2	Bagasse from Doiwala was used. Well-cooked pulp. The alkali treatment was not given during bleaching. This bleached pulp was used for blending with sabai grass pulp for making printing paper.
6	18	1 : 6	153	6	..	..	3·7	..	Bagasse from Doiwala was used. Well-cooked pulp. No alkali treatment during bleaching. This bleached pulp was used for blending with *ulla* grass pulp for making printing paper.

* The % is expressed on the basis of the depithed bagasse (oven-dry).

TABLE VIII.—PILOT

Strength properties of papers from pulps described in Table VII Serial Nos. in this Table

1	2	3	4	5	6		7		8	
Serial No.	Freeness after the addition of size, etc.	Ream weight 20"×30" – 500	Basis weight*	Thickness	Tensile strength (Schopper)		Breaking length*		Stretch	
	c.c. (C.S.F.)	lb.	g./sq. metre	mils (1/1000 inch)	kg. breaking strain for 1 cm. width		metres		%	
					Machine direction	Cross direction	Machine direction	Cross direction	Machine direction	Cross direction
1	150	33·6	73·1	4·20	2·88	1·65	3940	2260	1·1	1·9
2*a*	135	33·1	71·6	3·90	2·93	2·21	4090	3090	2·0	2·5
2*b*	135	28·9	62·4	3·55	2·30	1·67	3690	2680	2·0	2·3
3	190	31·9	69·7	4·20	3·70	1·90	5310	2730	1·8	2·8
4	230	29·7	64·6	3·70	2·63	1·39	4070	2150	1·8	2·8
5	190	27·4	60·0	3·20	3·20	1·60	5330	2670	1·6	2·3
6	190	29·0	63·5	3·50	2·85	1·70	4490	2680	1·5	1·9

* For calculating this, oven-dry weight of the paper was used.

PLANT TRIALS

correspond to the Serial Nos. in Table VII. The papers were conditioned at 65% R.H. and 72°F.

9		10		11	12	13		14
Tearing resistance (Marx-Elmendorf)		Tear factor*		Bursting strength (Ashcroft)	Burst factor*	Folding resistance (Schopper)		REMARKS
g.				lb./sq. inch		double folds		
Machine direction	Cross direction	Machine direction	Cross direction			Machine direction	Cross direction	
30·3	33·5	41·5	45·8	16·4	15·8	5	5	Printing paper from 100% bagasse pulp; 9% china clay and 1% titanium dioxide were used as fillers.
36·1	40·6	50·4	56·7	19·5	19·1	9	8	Printing paper from 100% bagasse pulp; 3·5% titanium dioxide was used as a filler. Sample is appended in this bulletin.
29·8	32·6	47·8	52·2	16·4	18·5	7	6	Printing paper from a mixture of 90% bagasse pulp and 10% bagasse pith; 3·5% titanium dioxide was added as a filler. Sample is appended in this bulletin.
42·7	43·2	61·3	62·0	23·6	23·8	26	12	Writing paper from 100% bagasse pulp; 2·3% titanium dioxide was added as a filler. Sample is appended in this bulletin.
38·6	46·6	59·8	72·1	19·8	21·6	31	10	Printing paper from 80% bagasse pulp and 20% bamboo pulp; 7·5% china clay and 2·1% titanium dioxide were added as fillers. Sample is appended in this bulletin.
34·3	36·6	57·2	61·0	20·2	23·7	22	14	Printing paper from a mixture of 70% bagasse pulp and 30% sabai grass pulp; 20% china clay was added as a filler. Sample is appended in this bulletin.
32·4	36·5	51·0	57·5	19·5	21·6	10	9	Printing paper from a mixture of 70% bagasse pulp and 30% *ulla* grass pulp; 20% china clay was added as a filler. Sample is appended in this bulletin.

TABLE IX

Strength properties of the printing paper made at the Shree Gopal Paper Mills

The paper was conditioned at 65% R.H. and 80°F. before test. The ash content of the paper was 7·8%

	Property	Printing paper from a mixture of 70% bagasse pulp and 30% bamboo pulp
1.	Freeness c.c. (C.S.F.) (at the breast box)	80
2.	Ream weight in lb., $17\frac{1}{2}'' \times 22\frac{1}{2}''$—500	17·0
3.	(*a*) Basis weight* g./sq. metre	57·1
	(*b*) Basis weight (at 65% R.H.), g./sq. metre	60·7
4.	Thickness, mils (1/1000 inch)	3·30
5.	Bulk, c.c. per g.	1·38
6.	Tensile strength (Schopper), kg. per cm. width	
	(*a*) Machine direction	2·24
	(*b*) Cross direction	1·40
7.	Breaking length*, metres	
	(*a*) Machine direction	3920
	(*b*) Cross direction	2450
8.	Stretch, %	
	(*a*) Machine direction	1·9
	(*b*) Cross direction	2·0
9.	Tearing resistance (Marx-Elmendorf), g.	
	(*a*) Machine direction	33·4
	(*b*) Cross direction	36·9
10.	Tear factor*	
	(*a*) Machine direction	58·5
	(*b*) Cross direction	64·6
11.	Bursting strength (Ashcroft), lb./sq. in.	15·3
12.	Burst factor*	18·8
13.	Folding endurance, double folds	
	(*a*) Machine direction	16
	(*b*) Cross direction	10

* For calculating this, oven-dry weight of the paper was used.

FIRES AND THEIR ECOLOGICAL EFFECTS IN MADHYA PRADESH

BY C. E. HEWETSON, I.F.S.
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1. The article in the January *Indian Forester*[1] by Dr. Gorrie tempts me to try and put down some observations on this subject. They are not original or deep but it may be useful to express them so as to try and arrive at an agreed corpus of knowledge.

2. The observations concern only conditions in Madhya Pradesh. The forests are either mixed deciduous or sal, the rainfall varies between 20 and 100 inches. The rains usually last from June 15th to September 15th. The period between the end of one monsoon and the beginning of the next may be completely rainless or more usually there are periods of rain in any of the months but more commonly in October to February. The fire season varies in length but normally may be taken as March 15th to the break of the monsoon. The leaf fall takes place from December to April but the main fall in ordinary mixed forest is in March. The new leaf flush starts from April but the leaf canopy only becomes dense after the rains have started.

3. *Fires and the rate of erosion*

(*a*) Measurement shews that the run off from a burnt forest floor is as great as from bare ground. The trees as such until they have a fall canopy of leaves have no effect on breaking up heavy tropical rain. The leaves are only effective when fully developed and even then the drip from large leaves may cause erosion. The influence of forests on run off is due to the leaf litter covering the surface and acting as a cushion between the rain drops and the soil particles. Therefore, a fire which removes the leaf fall destroys the anti-erosion effect of a forest. This is an important distinction. Early burning before leaf fall may do no harm. All fires after leaf fall are bad.

(*b*) The leaf fall is important when the leaf layer is complete but in open forest the leaves are not sufficient to cover the surface. They are also blown about and dispersed by the strong winds of April and May. In such open forests there is usually a growth of grass and other vegetation such as thorny shrubs. This grass layer except where the grazing incidence is heavy is a good soil stabilizer and a complete grass layer allows little erosion. It is such drier open grassy forests which are most easily burnt in early burning but the grass cover is destroyed and the ground will be exposed to the early monsoon showers. Early burning in such areas will tend to increase erosion.

4. *Fires and Vegetation*—The interaction is very complex and the effect of fires may vary widely according to the angle from which we approach the problem. I will confine myself to several examples :—

(*a*) Completely successful fire protection has been maintained for 75 years over most of the Allapalli Forests and in Bori Reserve. These are predominantly Teak Forests. The effect has been that the teak trees are now sound and free from fire scars. There has been an appreciable fall in the time taken for a tree to reach the exploitable girth[2] and there has been a great development of the undergrowth such as bamboos, Petalidium, etc. In fact to such

an extent that regeneration of tree species by natural means is inhibited. From the erosion point of view the cover is the optimum and even after heavy rain up to 5 inches in a day the streams are only slightly turbid and in one or two days are running crystal clear. This in a sense is the ideal.

(*b*) In most forests, however, uninterrupted protection is not possible and the forest gets burnt at intervals. During the unburnt period much inflammable material collects and when a fire does come it is very hot and does much damage (particularly if it occurs in May) and alters the vegetation by killing out regeneration and shrubby growth. The forest is much more open after such a fire. The damage is much more severe than that caused in areas which are burnt annually and in which there is little to burn. If such areas are burnt early every year the fires do less damage and the vegetation is stabilized in a more or less open condition. In open forest where grass develops and there is only light grazing annual fires may be so hot that tree regeneration is killed out and such areas remain in a condition of woodland savanah. In this condition, the plant cover is poor both for control of the rate of erosion and for improving the value of the forest. Early burning may do a little good in such areas but often the interval between the time when the forest can be burnt at all, and the period it burns fiercely is so short that it is impracticable to burn off the whole area.

(*c*) *Sal Forest*—In south Raipur and Bastar we have two continuous forests of which one has been fairly successfully protected for 70–80 years and Bastar is burnt annually. Burnt annually does not mean only one fire but rather that the forest is burning continuously throughout the fire season, as leaves turn yellow and fall. In the Bastar sal forests sheet erosion is rapid : in south Raipur erosion is nil. For erosion the fires are bad : for the forest itself there is little difference as the fires are not at all hot and the trees are healthy. Natural regeneration is perhaps less and any form of regeneration by the uniform system is ruled out in the annually burnt forest.

(*d*) The early burning advocated by Dr. Gorrie is really of importance mostly in young woods where complete protection is difficult or impossible and where late fires are disastrous.

(*e*) One of the beliefs of the aboriginals is that the ashes from the burnt leaf layer in the forest is washed down into their fields and gives them much needed mineral fertilizer. Thus they burn off the forests with almost religious fervour. In fact they may be said to regard moderate erosion as a "good thing".

5. When we consider the entire catchment area of a watershed, say the Damodar or the Hirakud dam on the Mahanadi, we should find out how much silt is supplied by each class of land : and how much of the catchment area can be helped by fire protection. Considering the 100 crores or so which the dams cost it seems a pity that a lac of rupees has not been spent on finding out what are the basic facts of the rate of erosion and where the silt load comes from. Following on this we should find out what is the effect of fire protection and the different forest vegetation on the rate of erosion. We can then evaluate the roll of fire protection and how much it is worth spending on it.

6. If any conclusion is to be drawn it is that complete 100% fire protection is the ideal both for reducing the rate of erosion and for the vegetation. However, 100% successful

fire protection is possible only in exceptional cases. Elsewhere short periods of successful fire protection followed by a hot and late periodic fires are very bad for the vegetation. However, it is probably less unfavourable for erosion as the forest floor is bare only one year in 4 or 5. Burning well stocked forest annually if it can be done before leaf fall, reduces the chances of fires later in the season, and though it will tend to kill out and prevent the regeneration of fire tender species, it will not affect fairly fire resistant species. It will, therefore, tend to stabilize the forest at a pre-climax not far removed from the true climatic climax. Early burning in open grassy forest, where the grass is more important than the fallen leaves as a soil stabilizer, is bad for control of erosion, and owing to the usual short period between the grass burning – and the grass burning fiercely, bad for the regeneration of tree species and tends to stabilize the vegetation at a pre-climax far removed from the climatic climax.

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PLACE OF STATISTICS IN SCIENTIFIC RESEARCH*

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A prominent scientist in our country has often been heard remarking: "Statistics is a good slave, but a bad master". This misleading slogan is based on a misconception of the role of modern statistical methods in scientific investigations on technological and industrial problems requiring empirical experimentation. The role of statistics is neither that of a slave (not even of a servant) nor that of a master. It is the same role that the various subject-matter sciences assume toward one another when they combine forces to achieve goals that none could attain alone.

We have to distinguish between two main concepts of statistics. The first concept, which is historically the older, regards statistics primarily as the exhaustive and routine compilation of numerical data and their arrangements into tables capable of revealing the required information either at a glance or at least without any mysterious mathematical manipulations. The second and the more modern concept of statistics regards it as the science of drawing, by reasoning depending on the theory of probability, generally valid inferences from particular bodies of data, acquired either by a sampling process or as a product of experiment.

The confusion mostly arises from the fact that the same term 'statistics' is used for both concepts. The second concept is, however, often referred to as 'statistical methods'.

The word 'statistics' is related to 'State' and originally referred to data concerning the State ; for example, data about the population, taxes, taxable property, foreign trade, etc. The collection, compilation and interpretation of statistics of this type have probably been going on for at least as long as governments have existed.

Until about sixty or eighty years ago statisticians were primarily concerned with the collection of data of interest to the State. Since then, the modern concept of statistics began to loom on the horizon developing methods that have found fruitful application in one branch of science and technology after another and attaining a central position in the biological, physical and engineering sciences and in mass production and distribution in industry.

The scientific method consists of the sequence – hypothesis, experiment, conclusion. Of these, the last part, namely, conclusion, is essentially statistical. It involves measurement of the fallibility inherent in the process of generalizing from particular results and, therefore, belongs to the domain of modern statistics.

In most problems, administrative or scientific, complete information cannot be obtained and partial information, either by experiment or a sampling process, must be sought and used. The statistician's task is to provide rational principles and techniques that tell when and how judgements can be made on the basis of this partial information, and what partial information is most worth seeking. In short, statistics provides a scientific method for making wise decisions in the face of uncertainty.

In an attempt to draw reasonable conclusions, the statistician calls upon the calculus of probability to find out how much confidence to place in the results of the experiments or sampling enquiries.

Workers in any field of science come to regard their experimental techniques as being peculiar to that field of science. They are unaware of the fact that there is a *science of experimentation* underlying all the experimental sciences. This is the *science of the design of experiments*.

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* Summary of the Presidential Address delivered in the Section of Statistics at the 41st Session of the Indian Science Congress held in Hyderabad-Deccan from 2nd to 8th January, 1954.

One of the most important contributions that statisticians have made and are still making to the advancement of science is in the field of experimental design.

The principles which form the basis of the modern theory of the design of experiments were developed by R. A. Fisher at Rothamsted Experimental Station about three decades ago. Three main principles are involved : replication, local control and randomization.

It is common knowledge in any field of science that a set of experimental units can be partitioned into groups which are more homogeneous than the whole set. This calls for the application of the principle of 'local control'.

Randomization gave one an assurance that due allowance would be made for the extraneous sources of variation.

A devise which is of considerable importance in empirical experimentation is that known as factorial design. In a factorial experiment the effects of a number of factors are simultaneously investigated by including all combinations of various levels or variants of the different factors.

The advantages of factorial design are considerable. It confers greater efficiency, comprehensiveness and a wider inductive basis to the experimental results and their interpretation. Its principal advantage is in the detection of so-called interaction effects.

The development of the design of experiments has been inspired largely by the needs of agriculture and biology. Statistical methods have proved of great value in many branches of biological investigations, especially in genetics, and they have brought into the realm of exact science, sections of biological and agricultural science, that could previously be described only as observational.

Statistics has also entered the realm of the so-called exact sciences of Physics, Chemistry and Engineering. Modern theories of matter have a statistical basis, and the scientists have to free their minds from the limitation of thinking only in terms of individual things, exact laws, and unique quantities determined with perfect precision. They have to comprehend aggregates, statistical laws, and quantities subject to errors and variations that occur with various probabilities.

In physics and chemistry the "old" methods were supposed to be good enough for a long time, but modern statistical methods are now spreading, chiefly through consultants, at a great rate in many advanced countries.

A change in the role of the Statistician from that of a mere analyzer and interpreter of data to that of co-planner in scientific investigations was begun by R. A. Fisher, founder of the science of the statistical design of experiments.

The cardinal rule for making effective use of the statistician is to call him in at the planning stage of an investigation. Too often the Statistician is called in "to the rescue" after the experiment has been finished and difficulties have been encountered in the interpretation of the data.

The statistical approach is so fundamental to the modern way of looking at things – the affairs of everyday life as well as scientific theories and experiments – that it should form part of the mental equipment of the educated man, which it is not at present. The need of the hour, however, is to educate those among the experimental scientists who have to be weaned from the belief : "I do not need statistics in my work".

DIAPER AND MARQUETRY

BY KASTURI RAMACHANDRA RAO, M.E.
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The art of decoration and floral work is not a new one to the present generation but it is as old as one can think of. As a matter of fact it has been handed over from generation to generation as a legacy and every generation has tried to improve it.

In good old days the articles of furniture and boxes were decorated with (i) floral veneers, (ii) inlay work, (iii) fret work and (iv) marquetry, but a diaper work has recently been developed using all the above in decoration work. On account of the similarity in the turn out of the designs and working one may feel that marquetry and diaper are the same and that "diaper" is a new name coined for it. But the following descriptions will make the distinctions quite clear.

(1) *Floral veneers*—The floral veneers are obtained from knot of logs and roots and are fixed or glued to the surface of article.

(2) *Inlay work*—The patterns are carved and chiselled out in a piece of wood and the shells, made out of ivory, stones, metals, small pieces of coloured woods are inserted and fixed with quick setting glues.

(3) *Fret work*—It is a piece of perforated work. It is an ornamental design formed of bands or billets variously continued, but most frequently arranged in rectangular forms.

(4) *Marquetry work*—It is of two distinct types. First type can be accurately described as inlay. The design is out lined on the surface to be decorated and the surface is sunk within these lines by 1/8th of an inch and small pieces of light and dark coloured woods are fitted therein. (ii) The second type involves a process of cutting, assembling and inlaying of veneers of various light coloured woods on a ground or base veneer of dark colour.

The method of cutting the patterns or designs in the veneers varies in details according to the floral or other designs and the general process followed is as under.

(*a*) The design is drawn on a paper and lines are perforated.

(*b*) The layers of veneer to be used in the pattern and for the ground or base are secured either with pared pins or glued together with a sheet of paper intervening to enable easy separation.

(*c*) The perforated paper having the design pasted on them to the top and the set is gripped in the (clamps) of the Donkey, i.e., marquetry cutters vice bench.

(*d*) Then the design is cut along the lines with the frame saw.

(*e*) The veneers are then separated by splitting along the interposed papers or by withdrawing the rims. Thus one can get many layers of veneer for every part of the design.

Thus every part of the design is cut separately and then assembled.

(*f*) The next operation is to fix with an adhesive the selected cut pieces of veneer into the sunken space cut in the base layer. After this on the assembled panel a sheet of paper is glued over to keep the pieces in position and the

whole thing is allowed to dry. Thereafter the surface is planed, scraped and roughened with a toothing plane and then given a thin coating of the glue which is allowed to dry. The marquetry panel is then laid in position and held by the veneer pins and glued down by means of a hot caul. Finally the marquetry is removed from the caul and the paper scraped and the surface smoothened and polished.

Floral designs—The design is cut into convenient sections and the above process is followed.

Having known what is marquetry and the difficulties involved in processing it into full designs, the writer devised an easy and cheap method of obtaining similar and better without the use of elaborate appliances. This is called diaper work.

In diaper work no complicated technique is involved and even a layman can do the work if he has the necessary moulds (wooden moulds) and a small press that can give a pressure of 200 lbs. to the square inch and a set of carpenters tools. These are in addition to peeling and driers, etc., which are common to marquetry and diaper works. In diaper work cold setting glue the common casein, sodium floride glue, may be used.

Process—The glued veneers are placed one over the other with grain parallel to the length of the mould and perpendicular to the groves and pressed at 200 lbs. per square inch. Of course the coloured veneers are arranged in sequence according to the design required. This laminated block is released from the press and allowed to cure in the open under atmospheric conditions. Thereafter it is planed and cut or sliced with a saw into sizable veneers which in turn are reversed and glued, reassembled and pressed at 200 lbs. per square inch, for about 24 hours to 48 hours. The block is removed from the Press and cured and dried under atmospheric conditions. The thin dried under sheets or veneers are cut out of this block and nailed and glued to the sheet of plywood or wood or cardboard. So long as the angle of cut is the same, the same design is repeated in the veneers and a variety of symmetrical designs can be formed with them. In marquetry, however, this will not be possible unless great trouble is taken.

From the above it will be quite evident that the marquetry work can give designed sheet only and not the blocks but diaper work can furnish blocks and any number of designed sheets or veneers of any thickness therefrom and both the blocks and the sheets can be well used in flooring and on walls apart from their use in furniture and ornamental work.

Pathological Note No. 7

NEW AND NOTEWORTHY DISEASES OF TREES IN INDIA

Pit Canker Disease of *Siris* (*Albizzia procera* Benth.) due to *Fusarium solani* (Mart.) App. et Wr. sensu Snyder et Hansen

BY K. BAGCHEE

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Siris (*Albizzia procera*) grows naturally in the *tarai* region of sub-Himalayan tracts of North India. In admixture with other hardwood species it is cultivated in the taungyas of Uttar Pradesh for timber. It is also grown in the tea gardens in the Doon Valley as a shelter crop to provide light shade to the tea bushes. The young trees of *siris* of about 15 to 20 years are attacked by a highly virulent bark and stem disease which produces greyish black canker on the stem (Pl. I, Figs. 1 and 2), which has been referred to by Troup (1921) who mentions that the tree is subject to cankerous wounds as a rule where branches have been broken off. The canker in some cases extends up and down the trees almost approaching the base, 5 to 10 feet in length, and covers ¾ of the diameter of the trees approaching maturity. The trees are almost girdled, the crown drying up above the canker in extreme cases, but usually the stem breaks off at the place where the canker is deepest. The disease has been under observation for the last 15 years, many diseased trees being examined in the New Forest Estate and tea gardens in the neighbourhood, and isolations have been made of the fungus. The results are described in this paper.

Pathology—After a spell of about three weeks' frost in the months of January and February the canker is usually noticed because of the appearance of a water-soaked dull brown discoloration on the smooth greenish-grey bark on young trees of pole stage, 10–15 years age, at a height of about 6 feet from the ground. This discoloration is the initial stage of frost canker although it may be seen on any part of the stem but more often starts at the axil of small branches. A few weeks later longitudinal cracks appear in the discoloured areas and are followed by horizontal ones (Pl. II, Fig. 2). In summer the frost canker is healed up by the formation of callus tissues below the injured bark, the dead bark sloughing off later on. After the rains, in September, at the end of the growth season, with some of the healed up tissues the cracks reopen. Later on a brown stain appears along the edge of the callus tissues formed during the previous spring and exudations also appear of gum and coloured substances from the cankers apparently healed up during the early spring, indicating thereby the activity of some pathogenic organism. This process continues every year, till in the course of 3 or 4 years a layer of dead cells of sunken tissues extending over an irregular patch of about 12–15 inches wide develops (Pl. I, Fig. 1, the black scar higher up). The later stages of canker were studied from the older diseased trees from the tea gardens adjoining the Institute. Due to the killing of the cambium and sapwood and the attempt of the living tissues to check the advance of the fungus, callus tissues are formed along the edge of the canker in terraced formation delimiting the canker from the sound tissues. The canker extends and the formation of the sapwood and heartwood is stopped. The sapwood attacked by the primary pathogen, followed by other secondary fungi becomes friable and flakes off exposing the heartwood. The exposed heartwood also provides a breeding place for insect borers. After a few years as the canker develops, the wound carries into the tree at the original foci of infection, all combining produce an unsightly scar which can be noticed from a distance.

* Received for publication on 2nd February 1954.

Siris is a fast growing species, consequently where the canker is widest it was possible to determine approximately the age of the tree from the growth rings as also the age at which the initial cankers were formed on the stem.

The canker initially has a pinkish colour changing to reddish dark brown and finally brown greyish black colour after secondary infection by bacteria and sap stain fungi. After it has grown for 3 to 4 years there are attacks of borers followed by wood-peckers, which also help in the disintegration of the wood (Pl. I, Figs. 1 and 2). After a few successive rainy seasons the colour of the canker changes to almost black, exudation of resin, gum and colouring matters tannin, etc., adding to the dirty appearance of the wound, and the disease can be popularly described as the 'Pit canker disease' of *siris*.

In sections of the bark and sapwood from the edge of the canker and cankerous tissues the hyaline hyphae of the fungus are noticed along the cell wall and in the cell cavities. The young hyphae are hyaline changing to light brown to smoke colour in mass. The hyphae can also be traced to the external heartwood. In the later stage in the old canker, owing to secondary infection due to various moulds it is not possible to distinguish the primary pathogen on the old established canker.

Tissues along the edge of callus where initial stain was noticed and pieces of stained sapwood from the margin of the sunken tissue produced conidial heads representing *Cephalosporium* stage when incubated under a moist chamber (Text Fig. 1). But this fungus could not be observed on the tree itself although material was examined from the diseased trees at different seasons. On the dead bark and sapwood, sporophores of *Hypoxylon ferruginosum* were seen in autumn.

Isolation was attempted in the spring and autumn in 1949, 1950, 1951 and 1952 and *Fusarium* sp. was isolated from the diseased tissues from the initial stage of canker.

Inoculation experiments—*Siris* plants raised in pots from stump cuttings in the spring of 1948 were established in 18 months and threw out vigorous new shoots and attained a height of 4 to 6 feet (Pl. II, Figs. 2 and 3) in three years when they were inoculated in the laboratory. The stems of the plants were wounded at a height of 12″ to 18″ from the soil, some also on the emergence of small branches, by using a sterilized cork-borer, slashing the bark with a sterilized scalpel penetrating about $\frac{1}{4}$ inch of sapwood below the bark and by vertically lanceting the surface bark with the scalpel. Cultures of *Fusarium* sp., of 5 to 7 days old, both monosporous and polysporous, in malt agar media, were introduced into the wound which was afterwards covered with sterilized cotton-wool and gauze and cellophane sheets. Also spores in suspension in sterile distilled were injected by a short-needled hypodermic syringe in some plants, and the wound was immediately covered with dressings as before. The bandages were removed from six to ten weeks after the inoculation experiments. The inoculated plants were maintained in pots till the following May when they started looking sickly due to being root bound in the pots and were finally transferred to the ground in the Silvicultural Experimental Nursery, when they revived in the course of 3 to 4 weeks.

Inoculation experiments were conducted on 28 plants in pots in July 1951 and 12 plants of 4 years of age of 7 to 10 feet height from the ground in August 1952.

When the incisions were examined 4 weeks after inoculation, activity of the fungus was noticed along the injured bark in all 28 plants inoculated, particularly along the periphery of the lesion by the discoloration of the bark spreading from the edge inwards, and by the exudation of gum. The hyphae of the fungus were also noticed in the sections of the discoloured tissues (Text Fig. 10).

Re-isolation of the patheogen from 6 out of 28 plants was done 8 weeks after inoculation in which healing of the wound by the formation of callus was taking place, indicating thereby some degree of fungal activity in the initial stage in all plants inoculated. Also re-isolation made 12 months after inoculation from plants which did not show any apparent sign of infection gave indication that in the host *F. solani* remains in the living condition for a long time before it is finally inactivated. From the above experiments it is evident that *F. solani* causes systemic infection on *A. procera*.

Six out of 15 plants in which the wounds healed up early were also re-inoculated in the following year without any result. The plants are maintaining a healthy condition although almost 3 years have passed. Six plants inoculated by hypodermic syringe with spore solution did not show any sign of infection, the wounds having healed up in 8–10 weeks. From the above observations it is evident that some trees are immune to the attack of *F. solani*, otherwise there would have been widespread outbreak of the disease in the localities through natural infection of the fungus taking place by air-borne spores.

Cultural characters—(1) *On Malt agar media*—Growth quick, mycelium appressed with scanty aerial hyphae becoming floccose after 3 days; mat covered with a meliaceous deposit by six days, small imperceptible colonies of pionnotes appearing after one month; microconidia 0–1 septate, fusiform-elliptical, $5–12\cdot4 \times 2\cdot6–4\cdot3\ \mu$, macroconidia 2–5 septate, sickle-shaped, $22\cdot0–43\cdot8 \times 4\cdot3–6\cdot5\ \mu$.

Colour of the medium changing to light 'flesh pink' after three weeks.

(2) *On Brown's media*—Growth quick, mycelium short cottony on the inoculum, changing to appressed, sodden in the advancing zone followed by cottony to wooly-cottony mycelium, growth vigorous after 4 days concentric zonations appearing at regular intervals behind the advancing zone, mat covered with a meliaceous deposit after 7 days, no pionnote formation or change in colour even after one month; microconidia 0–1 septate, fusiform-elliptical, $5\cdot5–13 \times 1\cdot7–2\cdot6\ \mu$, macroconidia 3–5 septate, sickle-shaped, $33\cdot2–43\cdot2 \times 3\cdot5–4\cdot0\ \mu$.

(3) *On oat-meal agar*—Growth quick, mycelium appressed with scanty aerial hyphae changing to floccose after 48 hours, white spots appear after 72 hours, mat sodden on the 4th day with pionnotes appearing on the 5th day covering the mat in the form of big colonies which appear during the next 2 days; microconidia 0–1 septate, fusiform-elliptical, $5–14\cdot6 \times 2\cdot6–4\cdot6\ \mu$, macroconidia 2–6 septate, sickle-shaped, $30\cdot6–51\cdot8 \times 4\cdot3–5\cdot8\ \mu$.

Colour: light 'flesh pink' all over the mat.

(4) *On 2% potato-dextrose agar*—Growth quick, mycelium short cottony changing to wooly-cottony in 3 days with massing of hyphae near the inoculum; on the 4th day mycelium is sodden, colonies of pionnotes in close clusters appearing on the 5th day, spreading all over the media in 7 days; microconidia 0–1 septate, fusiform-elliptical, $5\cdot8–12\cdot4 \times 2\cdot6–5\cdot5\ \mu$, macroconidia 1–4 septate, sickle-shaped, $17\cdot5–32\cdot0 \times 4\cdot3–5\cdot8\ \mu$.

Colour changing to 'pale vinaceous' deepening to 'vinaceous' in the neighbourhood of the inoculum.

(5) *On 5% potato-dextrose agar*—Growth characters and reaction comparable to growth and reaction on 2% potato-dextrose agar, growth faster and colour reaction more intensified in this media, pionnotes formed after 5 days covering the slant in a week; microconidia 0–1 septate, fusiform-elliptical, $6\cdot5–12\cdot0 \times 2\cdot9–5\cdot8\ \mu$, macroconidia 1–3 septate, sickle-shaped, $16\cdot0–34\cdot3 \times 4\cdot3–6\cdot0\ \mu$.

Colour changing to 'deep vinaceous' and 'corinthian red'.

FIG. 1.

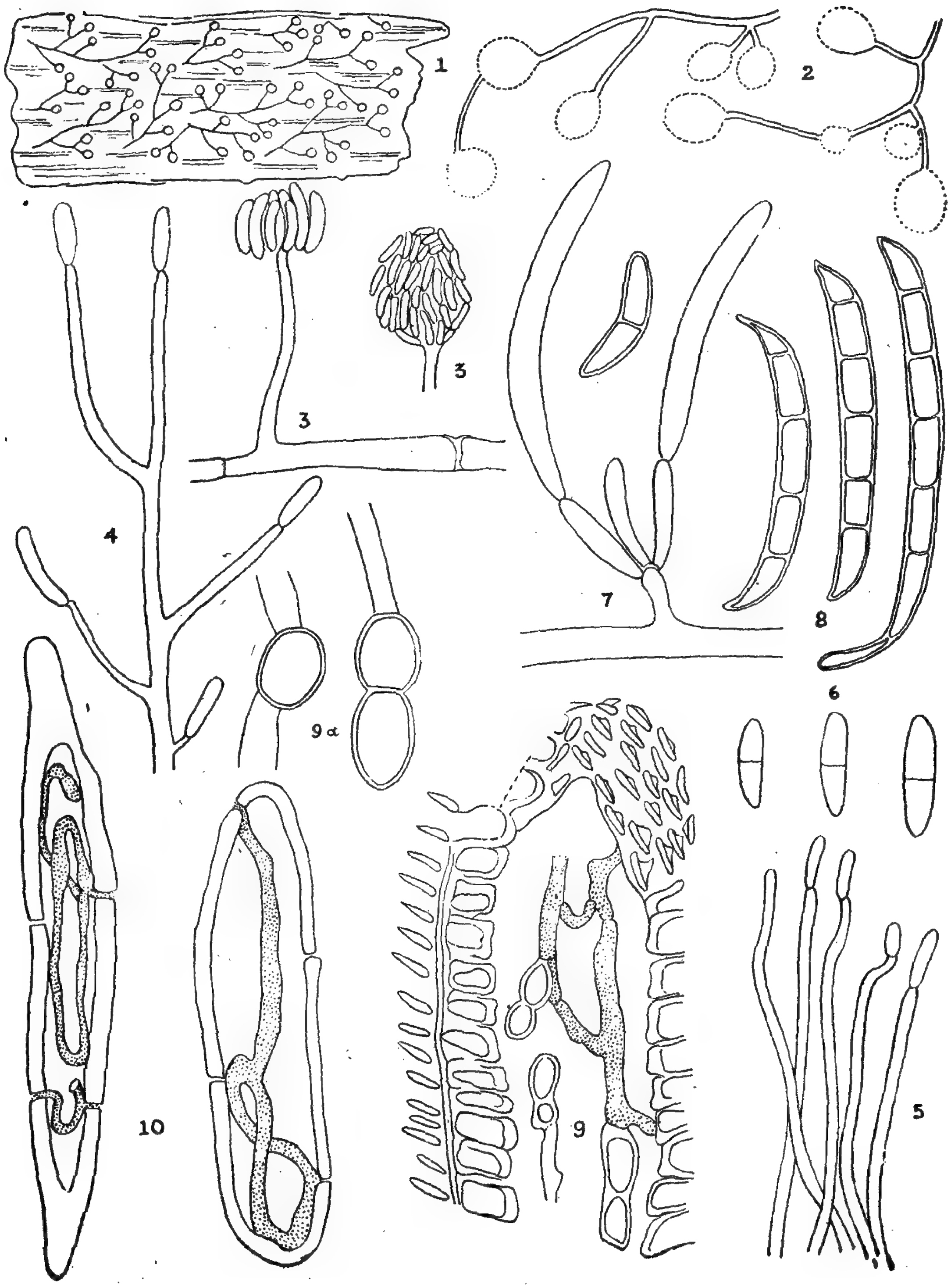
FIG. 2.

PLATE 2.

FIG. 3.

FIG. 2.

FIG. 1.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(6) *On the sapwood stem pieces of Albizzia procera after removal of the external bark, maintained in aseptic condition in sterile Roux tubes containing distilled water in the bulbous portion*—Growth apparent 3 days after transfer, mycelium wooly-cottony, growth vigorous producing exuberent mycelia on autoclaved woodblocks covered with thin or thick patches of fungus in 7 days ; growth floccose, thin extending downwards from the region of initial inoculation on the unautoclaved blocks ; pionnotes formed after 7 days on woodblock later spreading from wood into water in the bulbs forming a scum over the water surface ; microconidia 0–1 septate, fusiform-elliptical, $6 \cdot 0$–$13 \cdot 0 \times 2 \cdot 6$–$5 \cdot 0\,\mu$; macroconidia 3–4 septate, sickle-shaped, $27 \cdot 0$–$44 \cdot 0 \times 3 \cdot 1$–$5 \cdot 5\,\mu$.

Colour changing to 'venetian pink' and light 'alizarine pink' deepening to 'madder brown' on the woodblocks ; 'pale salmon color' 'pale flesh colour' and light 'alizarine pink' on the pionnotes.

The colour reaction is intensified on the autoclaved woodblocks.

Hyphae aerial erect, hyaline, thin-walled, uniformly tubular, septate at long intervals, 2–$2 \cdot 5\,\mu$ wide, conidia are formed from short branches also abstricted from the apex of the erect hyphae (Text Figs. 4 and 5), where they adhere to each other by mucillagenous substance forming *Cephalosporium* heads (Text Figs. 2 and 3); conidiospores unicellular $3 \cdot 5$–$9 \cdot 1 \times 1 \cdot 4$–$2 \cdot 8\,\mu$, mean $6 \cdot 2 \times 1 \cdot 8\,\mu$; and appressed hyphae, thin-walled, nodose with irregular width, length up to $40\,\mu$, width $3 \cdot 0$ to $5 \cdot 0\,\mu$, sometimes with swollen ends or club-shaped structures.

General Description of Fusarium sp.—Typical sporodochia absent, pionnotes formed in all media except Brown's media, colonies globose or sub-globose, 'pale salmon', 'pale flesh color', 'light alizarine pink' ; chlamydospores present in the wood (Text Fig. 9) and media, sub-globose to ovoid, 14–18×11–$16\,\mu$ in wood and $5 \cdot 0$–$11 \cdot 6 \times 5 \cdot 0$–$8 \cdot 7\,\mu$ in culture ; microconidia dominate as *Cephalosporium* stage, i.e., in heads, held together by a mucilaginous matter, varying in form from sub-globose to oval, fusiform-elliptical, 5–$14 \cdot 6 \times 1 \cdot 7$–$5 \cdot 8\,\mu$, 0–1 septate (Text Fig. 6) ; macroconidia sickle-shaped (Text Fig. 7), 1–2 septate few, 3–5 septate many, occasionally 6-septate, the last one being the foot-cell (Text Fig. 8), initially straight, curving when mature. 1-septate spores measure $17 \cdot 5$–$18 \cdot 9 \times 3 \cdot 3$–$4 \cdot 3\,\mu$; 2-septate $19 \cdot 8$–$21 \cdot 9 \times 3 \cdot 9$–$4 \cdot 6\,\mu$; 3-septate $18 \cdot 2$–$39 \cdot 4 \times 3 \cdot 6$–$5 \cdot 8\,\mu$; 4-septate $29 \cdot 0$–$40 \cdot 8 \times 4 \cdot 2$–$5 \cdot 1\,\mu$; 5-septate $34 \cdot 3$–$51 \cdot 8 \times 4 \cdot 2$–$6 \cdot 1\,\mu$.

Colour of the media changing to 'pale flesh', 'pale vinaceous' deepening to 'madder brown' on the inoculated woodblocks. No change in colour in Brown's media.

Measurements of macroconidia of Fusarium solani Mart. and var. minus Wr. and Rg. and Fusarium sp. from A. procera

	3-septate	4-septate	5-septate
1. *F. solani* (Mart.) App. and Wr.			
	19–$50 \times 3 \cdot 5$–$7\,\mu$.	aver. $42 \times 5 \cdot 6\,\mu$.	32–68×4–$7\,\mu$.
2. *F. solani* (Mart.) App. and Wr. var. *minus* Wr.			
	20–$41 \times 3 \cdot 5$–$6\,\mu$.	$35 \times 4 \cdot 7\,\mu$.	30–$50 \times 3 \cdot 7$–$6\,\mu$.
3. *Fusarium* sp. (from *A. procera*)			
	$18 \cdot 4$–$39 \cdot 5 \times 3 \cdot 6$–$5 \cdot 8\,\mu$.	29–$40 \cdot 8 \times 4 \cdot 2$–$5\,\mu$.	$34 \cdot 4$–$51 \cdot 8 \times 4 \cdot 2$–$6\,\mu$.

Identity of the Fungus—The fungus has been identified as *Fusarium solani* (Mart.) App. and Wr. This determination is also confirmed from the cultural characters described above and compared with those given by Gilman (1950). Further, the size of macroconidia in the 3-, 4-, 5-septate spores as shown in the table appear to fall within the range, length and width, of *Fusarium solani* (Mart.) App. and Wr. var. *minus* Wr. (Gilman 1950, Wollenweber and Reinking 1935). Snyder and Hansen (1941) have re-grouped all the members under section Martiella into one species, *F. solani*, on the morphological characters, viz., configuration of the

fruit bodies (sporodochia and pionnotes), curvature, septation and measurement of the macroconidia. As some are virulent parasites and others saprophytes, on the basis of pathogenecity Snyder and Hansen have re-grouped them in five forms (formae), and in the first, *Fusarium solani* (Mart.) App. et. Wr. emend, *F. solani* (Mart.) App. et. Wr. var. *minus* Wr. has also been included.

Following the treatment of pathogenic cultural strains of *Fusarium* of the Martiella section by Snyder and Hansen I propose to name the fungus as *Fusarium solani* (Mart.) App. and Wr. emend Snyder and Hansen forma *Albizziae*. The type is deposited in the National Type Culture Collection (Forests), Forest Research Institute, Dehra Dun, Uttar Pradesh, India.

There are instances of both wilt and canker of woody trees due to the attack of *Fusarium* spp. and allied fungi. Wilt of *Dalbergia sissoo*, *Acacia arabica* and *A. catechu* due to the attack of *Fusarium* sp., now identified as *F. solani* (Mart.) App. and Wr. has been known in this region from a long time (Bagchee 1945). *Cephalosporium* represents the microconidial stage of *F. solani*. *Fusarium* sp. belonging to the section Elegans has been attributed to the wilt of *A. julibrissin* (Hepting 1939). Also *Nectria haematococoa* Berk. et Br. which causes canker of *Tectona grandis* (teak) has its imperfect stage as *Hypomyces haematococcus*. (Berk. et Br.) Wr. The macroconidial stage of this fungus reproduced (Bagchee 1947) by culture on the living trees and in Brown's media as *Fusarium* sp. (cf. *F. solani* var. *eumerti* Wr.).

The elm wilt disease *Cerastostomella ulmi* Schwarz., is also disseminated by *Cephalosporium* spores representing a conidial stage of the fungus (May and Gravatt 1931, Creager 1935). Lastly, the form genus *Cephalosporium* contributes species which are pathogenic to the living plants; recently a canker on *Tsuga heterophylla*, the western hemlock, has been correlated to the attack by a *Cephalosporium* sp. (Denyar 1953). The first stage in the spore formation of the pit canker of *A. procera* described above is *Cephalosporium*, representing the first link in the chain, the second being the macroconidia of *Fusarium solani*.

The author wishes to express his indebtedness to Dr. W. L. Gordon, Plant Pathologist, Laboratory of Plant Pathology, Science Service, Department of Agriculture, Canada, University of Manitoba, Winnipeg and Dr. A. van Beverwyk of the Centralbureau voor Schimmelcultures, Baarn, Netherland, for the identification of the fungus. The author is thankful to Shri Y. N. Puri, M.Sc., Research Assistant, Mycology Branch, Forest Research Institute for giving constant attention and help during the experimentation and isolation of the fungus.

The colours described in the paper under inverted commas are based on 'Color Standard and Color Nomenclature' – Ridgway.

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ILLUSTRATIONS

PLATE I

FIG. 1.—A mature tree of *A. procera* showing the advanced stage of canker, the exposed heartwood attacked by borers, the holes along the edge of canker by the wood-peckers.

FIG. 2.—A mature tree of *A. procera* showing a basal canker, the exposed wood attacked by insects, and secondary fungi include heartrot and sap stain, and *Hypoxylon ferruginosa* at the edge of the canker shown by the scale.

PLATE II

FIG. 1.—The same tree as showing in Pl. I, Fig. 2 developing a second canker higher up.

FIG. 2.—Inoculation of a sapling of *A. procera* with the culture of *F. solani*.

FIG. 3.—Canker developing after about 18 months on the host inoculated with the cultures of *F. solani* through the borer wound.

TEXT FIGURES

FIG. 1.—Formation of *Cephalosporium* head producing microconidia along the edge of cankered wood of *A. procera* after keeping the diseased wood in the moist chamber for 2–3 days. × 40.

FIG. 2.—*Cephalosporium* stage with microconidia, on malt agar plates, showing formation of hypha through the conidial heads by proliferation, the spores being abstricted from the terminal hyphae are held up in masses in the gelatinous matrix (semi-diagrammatic). × 125.

FIG. 3.—A conidial head with numerous microconidia. × 540.

FIG. 4.—Microconidia abstricted from the tip of a branched aerial hyphae. × 540.

FIG. 5.—Microconidia abstricted from the tip of erect unbranched hyphae. × 540.

FIG. 6.—1-septate microconidia. × 1225.

FIG. 7.—Macroconidia developing on the conidiophore. × 1225.

FIG. 8 —Fully developed macroconidia, one with the footcell. × 1225.

FIG. 9.—Chlamydospores from a section of decayed wood. × 1225.

FIG. 10.—Hyphae in the fibre and parenchyma cell of decayed wood. × 1225.

ON THE NEED OF FOREST SOIL SURVEYS

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SUMMARY

The paper stresses the need and importance of conducting Forest Soil Survey for proper planning in forest management. Forest soil survey will delineate planting sites for afforestation and suggest potential possibilities of forest management apart from site classification. The selection of areas for afforestation should be based on land capability which assigns the best use of any land so as to make it permanently productive. The best land use is one in which land produces the maximum and deteriorates the least.

The paper gives detailed procedure for conducting forest soil surveys. The procedure of Erosion Survey has been described, which has its application in erosion control of forested areas to save the forests from deterioration, and for locating the sore spots or critically eroded areas where restoration work in the form of afforestation or reforestation is urgently needed.

The author points out that such Forest Soil Surveys should include an ecological (floristic) survey since the latter may be helpful in carrying planting operations and will afford an indication as to the type of forest growth that will be sustained by the site.

The paper concludes with a plea for conducting elaborate Forest Soil Surveys including land capability classification before putting any area under afforestation.

Introduction—Forest soil surveys provide us an inventory of the forest soil resources, which is very essential for proper planning in forest management. Forest soil surveys will define the areas adapted to silviculture and delineate the soils suitable for planting to different tree species. Soil Survey provides us the basis for all types of land use planning. Selection of areas for afforestation should be based on land capability classification which assigns the best use of any land so as to make it permanently productive. The best land use is one in which soil deteriorates the least and produces the maximum. Land capability classification is based on the capacity or potentiality of the land to produce. It does not necessarily reflect the present state of land, which may need the application of conservation practices or other treatments to bring this into a condition which will make it permanently productive. On the other hand if conservation practices are not able to transform an area into a more permanently productive condition that land must remain in a less useful class. For land capability classification Soil, Erosion, Present Land Use and other relevant data on socio-economic factors have to be taken into consideration. Such a land capability map should form the basis for the selection of areas for afforestation.

Soils unproductive and sub-marginal for agriculture may show great variation in forest growth. Forest site quality is basically a function of soil texture, topography, drainage, nature of organic matter, local climate and other physical and chemical soil conditions. Hence a study of these becomes imperative for site classification.

Forest soil surveys need to be conducted with the following three objectives :—

1. Forest site classification,
2. Genesis and classification of forest soils,
3. Practical working details about the afforestation and reforestation of certain areas.

Forest soil surveys to achieve these objectives should include a floristic survey along with soil survey. The latter may be very helpful in carrying out the planting, thinning and selective cutting operations in areas of varied topography.

Such forest soil surveys will provide us the following three types of maps :—

(*a*) Maps for planting sites,
(*b*) Maps indicating potential possibilities of forest management,
(*c*) Map showing forest soil types.

Soil Survey of areas which can and should be used for forestry—The wastelands, the cultivated uplands and ill-managed forests are the main sources of silt transport and need most protection from erosion. Out of the wastelands some of the gullies and poor type of uplands need to be afforested. To delineate such areas for afforestation a regular soil survey has to be conducted.

Some of the idle or fallow crop land, at present classified as crop land is essentially sub-marginal in character and will be available for forestry. All this, if planted up, will support some sort of tree growth, and distinct social and economic advantage may result from devoting it to forestry. An ecological survey conducted at the same time will afford an indication as to the type of forest growth that will be sustained by the site.

Procedure and Methodology—Air photographs serve as good base maps. Where air photographs are not available topographic maps or some suitable base maps of the area are used, and the area is traversed. The traverse is begun from or located in reference to a known point, compass bearings give the surveyor his direction and he may either pace his distance or measure them with a chain depending on the degree of accuracy aimed at. The whole area should be covered systematically and this will be possible only through a system of parallel traverses. The soil surveyor must observe all primary (major) and secondary (minor) soil characteristics along his traverse. At intervals along his traverse soil profile sites are chosen in the central position of an apparently uniform soil area for making a detailed examination. The soil-profile is the unit of study. Profile locations are fixed accurately on the base map used, by the principle of traversing. The soil boundaries between these traverses are interpolated. The soil-profile of dimensions 4×4 feet is excavated to the depth of the bed rock in the case of primary soils. At each profile site environmental factors pertaining to slope aspect and vegetation are described. As a general rule the essential features of forest soils can be learned by examining the soil to a depth of 6 or 7 feet.

The major horizons of a soil-profile should be marked out, based on colour change. These can be given the designations A, B, C and their sub-divisions. But, most times it is not possible without some laboratory study. Hence various textural layers with their depths should simply be numbered from surface on down to the parent material. With horizon boundaries located, the depth and thickness of each are recorded, together with the character of boundaries between them. Measurements are taken from the top of A_1 horizon. After measurement each horizon or layer is described under the headings of depth, colour, texture, structure, etc., and the data are recorded in the specimen form given in Table I.

A representative podsol profile of a forest soil is given in Fig. 1 which gives in general the various horizons met with in a podsol type of soil.

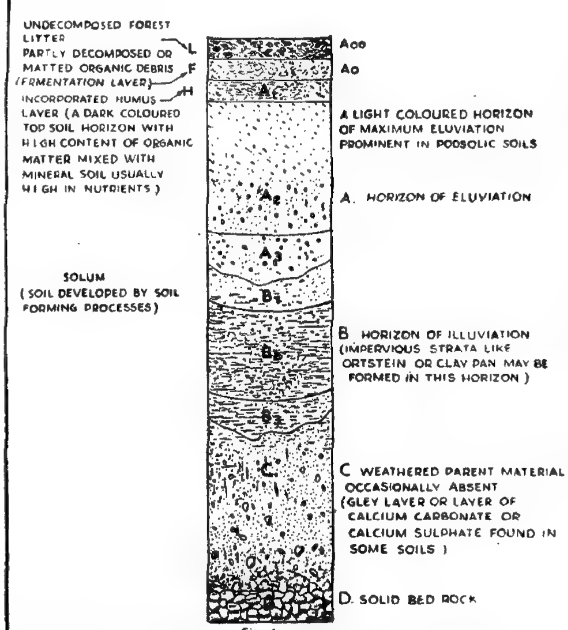

Fig. 1
PODSOL
DESIGNATION OF HORIZON IN THE PROFILE OF A FOREST SOIL

Some of the major and minor soil characteristics and associated land features that need to be studied are the following :—

A. Major Soil Characteristics :
1. Soil colour
2. Soil texture
3. Soil depth
4. Soil structure
5. Depth of water table.

B. Minor Soil Characteristics :
6. Water holding capacity
7. Drainage
8. Soil reaction
9. Soil organic matter
10. Inherent fertility
11. Type of parent material (geology).

C. Associated Land Features :
12. Topography
13. Erosion
14. Special features
(*a*) Stoniness
(*b*) Salinity and alkalinity
(*c*) Rock out-crops
(*d*) Hard or clay pan
(*e*) Gley layer.

TABLE I

Standard form for Soil Profile Descriptions

Location (Grid ref.) .. .. Area Date
Natural vegetation .. ..
Parent material .. ..
Physiography and Relief .. ..
Slope .. ..
Depths of water table .. ..
Erosion .. ..

Profile No.

Horizon	Depth (inches)	Thickness	Boundary	Colour Dry or Moist	Texture	Structure	Root distribution	Consistence	Soil Reactoin	Drainage	Special features like concretions of iron, calcium quartz and stoniness	REMARKS
				D M								
				D M								
				D M								
				D M								

Soil Samples Collected : Collected by :

1. *Soil Colour*—Soil colours are indicated by using Munsell's notations given in the standard Munsell color charts, and moisture condition is noted while describing colors.

2. *Soil Depth*—Depth as well as thickness of the various horizons are important in the growth of a forest because of the amount of water stored in the soil, and that available for plant growth. In addition, depth determines to a great degree the growth of the roots.

The forest floor (entire accumulation of organic matter on soil surface of an old forest stand) can be sub-divided into two or more layers. The uppermost layer is composed of relatively undecomposed freshly fallen litter (leaves, twigs and other plant remains), and is designated as 'L' or Aoo. Beneath this litter layer, a layer of actively decomposing organic debris is found, and is called the fermentation layer 'F' or Ao. In some soils and particularly in cool humid areas supporting coniferous forests, a humified or humus layer is found beneath the 'F' layer. This layer is called 'H' layer.

The actual thickness of these horizons vary widely because of fire and other disturbances. The horizons are well developed in podsol, and are found in most unburned forest soil. Horizon boundaries are described as to distinctiveness, i.e., abrupt, clear, gradual and diffuse, also according to topography, as smooth, wavy, irregular and broken. A shallow soil on an impervious sub-soil endangers the stability of trees, especially after thinnings and restricts root expansion.

3. *Soil Texture*—Soil texture refers to the relative proportions of the various size groups of individual soil grains in a mass of soil. With increase in fine material (silt and clay) in A and B the site index goes up. Soil texture is of great importance in forest planting and forest growth, apart from its significance in cuttings and thinnings. Since it greatly affects the intensity of cutting and choice of species which should be protected. The important textural classes in order of increasing proportions of fine separates are loamy sand, sandy loam, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay and silt clay. On the whole sandy soils and gravelly soils are best suited to species which develop a deep root system, while fine textured soils are best suited for shallow rooted species.

Hydrometer method of Bouyoncos for soil texture determination in Laboratory is the most suitable for needs of Forestry.

4. *Soil Structure*—Soil structure refers to the arrangement of primary and secondary particles into a more or less definite pattern. The importance of soil structure in soil productivity, soil permeability, water percolation, root growth, aeration can scarcely be overemphasized. Morphological classification of soil structure as given by Nikiforoff is a suitable one for use, which gives the following types of structures: platy, prismatic, columnar, angular blocky, sub-angular blocky, granular and crumb.

5. *Depth of water table*—Depth of water table is very important in determining the kind of growth. Site index goes up when water table may be in reach of tree roots. For planting site requirements there is a minimum depth of ground water table for each species. The lower limit of a forest soil is often delineated by the level of ground water or impermeable bed rock of a layer containing substances toxic to roots.

6. *Water holding capacity*—This physical character of soil has a great importance in determining site quality. The character of vegetation is determined not so much by the amount of available moisture in the soil, but by the amount of moisture at the driest periods during the growing season. Water holding capacity of soil is determined by saturating a soil sample and placing it in contact with a relatively deep column of medium textured soil and allow it to drain to a steady state approximating field capacity (water held in small pores against gravity). The soil moisture tension at field capacity is approximately $\frac{1}{2}$ atmosphere

and that at the point where plants permanently wilt is about 15 atmospheres. Moisture contained by soil between these two points represents the available water holding capacity of a soil. It is usually the finest texture layer within a depth of 4 feet that determines the water holding capacity of soil, and supply of available nutrient, i.e., in case of loose sandy soils, it is the upper humus layer which should be analysed, whereas in case of leached soil, it is the sub-soil layer. The whole soil profile should be considered in soil sampling.

The quantity of water that soils can hold in a form available for plant use is influenced mainly by the quantity of clay and organic matter in the soils, and the physical properties of clay. If clay exhibits above degree of swelling and shrinking on wetting and drying or has a low base exchange capacity it is probable that it also has a low available water holding capacity.

It may be that in some areas the moisture holding capacity increases invariably with soil depth, suggesting that deeper planting to put seedlings roots nearer those zones of better moisture supply may aid in plantation survival. Soil samples of successive 6 inches depths can be taken for determination of moisture in situ, and soil zones of highest moisture supply determined.

7. *Organic matter*—Organic matter and roots are noted in descriptions of the soil profile. Exact amounts of organic matter can be known only by laboratory analysis of soil samples.

The layers of organic matter that lie on the surface of forest soil are designated as under :

'L' for freshly fallen litter, 'F' for partially decomposed litter, and 'H' (humus layer) for rather completely decomposed litter.

Every tree species for its normal development needs a certain amount of organic matter. The minimum amount of organic matter in surface layer will vary for different species in their planting site. The amount and type of humus has a great influence on the growth of trees and possibilities of natural reproduction.

In general, litter from broadleaved trees decompose more rapidly than coniferous litter. The slower decomposition of conifer needle litter is in part due to the high resin content and low water absorbing capacity. Also, conifer needles remain in a loose, well aerated mass for a much longer period and do not pack with wetting. This makes the litter more susceptible to drying and results in slow decomposition. Effect of litter on forest soil is on the whole beneficial. *It prevents erosion by holding the soil in place. It adds to organic matter by* decay. Soil color by itself is not an exact measure of organic matter. The chemical role of litter and forest floor in maintaining or changing soil productivity depends chiefly upon their content of N, Ca, P & K. The amount of these constituents extracted from the mineral soil by the vegetation and returned to the surface in the litter vary with the species and with the amounts available in root zone of the soil.

Addition of forest litter to soils of poor sites increases forest growth and removal of forest litter or its excessive accumulation as raw humus deteriorates the site quality and decreases growth.

8. *Drainage*—External soil drainage (run off) is closely related to slope and internal drainage depends on permeability of the soil, and of the material beneath it. Both external and internal drainage determine the planting site.

9. *Soil Reaction*—Every tree grows in a suitable range of pH. Forest vegetation may tolerate wide range in pH. A study of soil reaction is essential to determine the planting possibilities at various reactions. The optimum reaction for most species is pH 5·0–6·5. B.D.H. Barium Sulphate soil testing outfit or Lamotte pH Kit, can be used for rapid determination of pH. The reaction is closely connected with the rate of decomposition of organic matter, and methods of slash disposal.

10. *Inherent Soil Fertility*—Lamotte quick soil testing kits can be used in the field for rapid determination of amounts of available nutrient elements. The amounts of available N, P, K, Ca, Mg and other elements, will help in determining as to what is needed in the way of fertilization to grow the tree crop. Under natural conditions a deficiency of these elements does not occur for tree growth. The amount of exchangeable or available calcium varies in forest soils depending on soil reaction. A knowledge of exchange capacity values which include the total effect of mineral and organic colloids, is useful not only in fertilizer practice, but in forest soil utilization, specially in selection of species for planting.

11. *Geology* (Type of parent material)—Soils inherit some of their properties from the parent material. The influence of the parent material on the genetical morphology of a soil profile varies greatly.

12. *Topography*—Topography plays an important part in the distribution of forest vegetation and selection of planting sites for various tree species. Exposure and orientation of slope is important from an ecological point. The greater the relative elevation and the greater the slopes, the more likely that an area will be well drained. Slopes facing the South and West, being more directly exposed, will tend to have less soil moisture, and will tend to support species generally found on other dry and exposed sites. Slopes facing North and East are more apt to retain soil moisture and to support mesophytic species.

13. *Erosion*—Erosion map should form a base for any planning. Basically erosion surveys classify four different factors, namely slope, land use, soil type and erosion. A reference (representative) profile for each soil type is taken as a standard to compare the extent of erosion, its intensity, types and distribution. Erosion is estimated by weighing other profiles with this reference profile. Erosion survey includes study of physiographic features also which influences the type of erosion. The different land forms, i.e., the plateau, escarpment, valley and rugged hilly regions will have different erosion types. Areas where people are engaged in mining and other industrial profession have neglected cropping and such areas are badly eroded as compared to the areas where people are on the land and are engaged in farming or areas under reserve forests.

For erosion mapping the following erosion classes have been recognized :—

Symbol	*Erosion Classes*	*Description*
0	No apparent erosion	..
1	Slight sheet erosion	Less than 25% of the solumn removed
2	Moderate sheet erosion	25–75% of solumn removed
3	Severe sheet erosion	More than 75% of solumn removed
7	Occasional gullies	Gullies more than 100 feet apart
8	Frequent gullies	Gullies less than 100 feet apart
9	Very severely gullied or intricate net work of gullies	..

The combination of the above erosion classes is shown on maps by a combination of numerical notations ascribed in each class. In case of gullies, the depth, width and frequency are noted.

a	3′ deep	*x*	3′ wide
b	3–5′ ,,	*y*	3–5′ ,,
c	5′ ,,	*z*	5′ ,,

Erosion survey and mapping the extent of degree of erosion has its application in the erosion of forested areas to save the forest from deterioration and further it points out the sites for afforestation and reforestation in the critically eroded areas.

14. *Special features.* (*a*) *Stony and Gravelly Land*—Stony land includes areas having enough stones and boulders to hide other soil characteristics.

Stoniness refers to the relative proportion of stones over 10 inches in diameter in or on the soil. The significance of the number and amount of stones depends upon the other soil characteristics.

Names used for coarse fragments in soils

Shape and kind of fragments	Size and name of fragments		
	Up to 3″ diameter	3–10″ diameter	More than 10″ diameter
Rounded and sub-rounded fragments (all kinds of rocks) ..	Gravelly	Cobbly	Stone (or bouldery)
Irregularly shaped angular fragments chert	Cherty (or angular)	Coarse cherty	Stony
Other than chert	Gravelly	Angular cobbly	Stony
	Up to 6″ in length	6–15″ in length	More than 15″ in length
Thin flat fragments, thin, flat sandstone, limestone and schist ..	Channery	Flaggy	Stony
Slat	Slaty	,,	,,
Shale	Shaly	,,	,,

From the silvicultural stand point mapping the presence of large stone is useful, as this eliminates the possibility of furrow planting. Where stones are present, notes on their number, size and distribution in the profile are no doubt essential in evaluating the use of capabilities of the soil and in correctly establishing phases for stoniness within soil types. But, at the same time detailed classification of stoniness is of little importance because stones do not interfere with spot planting.

(*b*) *Efflorescence*—It refers to the presence of various salts in crystaline forms as crust or pockets. Efflorescence consists mostly of soluble salts, particularly of sodium.

(*c*) *Rock outcrops*—Rock outcrop consists of exposures of bare bed rock. Mapping of rock outcrops is essential to delineate areas for afforestation, since such denuded areas are critical and must be protected from further erosion. Small rock outcrops can be shown by the standard symbol. Combination of rockiness and stoniness if it occurs should also be mapped. Types of rock outcrops should be mentioned according to kind of rock materials such as granitic, siliceous, sandstone, ferromagnesium and calcareous, etc.

(*d*) *Hard pan* (ortstein)—Depth of such hard pan, if present, must be noted. Development of hard pan may cause a deterioration of site for afforestation.

(*e*) *Gley layer*—Gley layer develops under the influence of ground water. Ordinarily gley soils occur in depressions and areas underlain by impervious substrata. The distance of gley layer from the surface influences the possibilities of natural reproduction, and stability of forest against wind, vigour and rate of growth. Forest cover is composed of a limited number of species which can tolerate deficiency of aeration. Such soils offer suitable site for more exacting species.

THE 1953 PLANTATIONS OF MISCELLANEOUS SPECIES OF COMMERCIAL IMPORTANCE UNDER THE FIVE-YEAR PLAN, BAHRAICH FOREST DIVISION, UTTAR PRADESH

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SUMMARY

In addition to raising miscellaneous plantations over a 300 acre compact block in Naubana, mulberry has been raised over 115 acres under the Five-Year Plan and miscellaneous species over 300 acres under the normal working plan prescriptions in Bahraich Division during 1953, besides carrying out the second year tending operations in the 1952 plantations aggregating to over 1,000 acres. During the 1953 season, therefore, new plantations have been raised over 715 acres and, in addition, second year tending operations carried out over 1,000 acres. This note deals with the 300 acre miscellaneous plantations raised in 1953 in Naubana under the Five-Year Plan.

A 300 acres rectangular plot, measuring 75 chains × 40 chains, was tractor ploughed in strips 8 feet wide alternating with 12-foot wide unploughed strips, during January and February 1953. The worked soil was allowed to bake in the hot sun during summer. A single line sowing of *shisham, toon, bhurkul, semal, siris* and *Ailanthus* was done in blocks a fortnight before the break of the monsoon. A barbed wire-cum-stockade fencing seven feet in height from the ground level was completed before starting the sowing. The germination, which was uniformly excellent all over the area completed by the first week of July, the first shower of good soaking rain having fallen on June 24, 1953. The timely soil working with tractors resulting in exposing the roots of weeds and grasses well before the commencement of the summer reduced the incidence of weeds very appreciably.

The tending operations started virtually with the germination of seed. These operations consisted of pulling out of the young weeds with roots and spacing out of the congested seedlings of tree species in the last week of July followed by a soil working with *khurpies* and *pharwas* during a spell of rainless period in September and October. The response in the development of the seedlings is wonderful and no further weeding is necessary. The spacing out of the seedlings was again carried out for the third time in October, 1953. The total cost of raising this plantation at the end of the first growing season comes to Rs. 75 per acre.

Selection of areas for raising plantations.—All the plantations raised in the past in the Champion's Sal Types A2, B3 and B4 in Bahraich Division have suffered significantly from drought, to a varying extent, in 1952–53. The worse affected species are sal, teak, mulberry and *asna*. In general, retrogression to a more xerophytic type is becoming significant. The dying off of natural *sal* from drought is alarmingly increasing. This is attributed to the ever increasing recession of the sub-soil water level beyond the reach of the tap root of tree species and is almost confirmed by a series of annual measurement of the water level in wells in the vicinity of forest areas.

It was, therefore, considered advisable to attempt to raise plantations in the more favourable areas where the sub-soil water level is not far from the ground level. With this object in view Doaba cpt. 10 locally known as Naubana, is selected as a suitable area. The top 6 inches to 10 inches layer of soil consists mainly of fertile loam while the soil below 10 inches is from loamy sand to almost pure sand. Water level is high, being only about 10 feet from the ground level. The area has always remained open to grazing. *Imperata* grass

dominates the entire area. There is practically no tree growth except a few solitary natural *shisham* trees. The gigantic size to which these trees are growing shows the potentiality of the soil to produce fine crops of *shisham* and other valuable miscellaneous species.

Soil working—The entire 300 acre plot was divided into four equal sub-plots of 75 acres each separated by 12-foot wide motor roads. The soil working consisted of ploughing with hired tractors in strips 8 feet wide alternating with 12-foot wide unploughed strips so that the distance between the ploughed strips is 20 feet from centre to centre. The strips are running north to south following the natural slope of the ground. The initial ploughing was done with a two furrow mouldboard plough, powerine operated Ferguson Tractor, during January and February 1953. This work was started immediately after the winter rains, i.e., by mid-January and completed before March, 1953. The average depth ploughed was 6 inches to 8 inches. The roots of the weeds and grasses did not go deeper than 6 inches and were completely uprooted and exposed to die in the hot sun.

This operation was followed by two harrowings with a John Deere Tractor during March and part of April 1953.

The last operation consisted of reploughing the ploughed and harrowed strips with a two furrow disc-plough and this was completed by the end of April 1953. The discs turned the worked soil, broke the remaining lumps of earth and thoroughly stirred it, again exposing the roots of grasses still lying buried in the soil. Above all the most useful and unique result obtained from the disc-ploughing was that the loose soil from either side of the ploughed strip was automatically piled up over the middle 4-foot wide section of the strip by the forward moving action of the discs leaving a 10 inches to 12 inches high raised seed-bed with drains on both sides. This was indeed a great achievement of the disc-plough. This made the drainage very efficient indeed the value of this is impossible to overestimate, notably in years of exceptionally heavy rainfall. The total cost of soil working works out to Rs. 24 per acre of the gross area or Rs. 80 per acre of the net area actually ploughed.

Fencing—Similar soil working was done over a 6-foot wide strip all round the 300-acre area along its periphery to grow a live hedge of *babul* and *khair*. This was completed in the first week of April 1953. A barbed wire-cum-stockade gameproof fence was erected along the outer side of this 6-foot wide worked strip all round the area. The height of the fence is 7 feet from the ground level. Seven strands of barbed-wire and three of stockade have been used in all. Only one gate at the entrance has been kept as, by experience, it has been found that the number of gates should be kept at a minimum as they only tend to increase the chances of admitting animals into the plantation area, defeating the very purpose of erecting a fence.

A very dense sowing of *babul* and *khair*, intimately mixed, was done in this 6-foot wide worked strip in the last week of May 1953. In addition, one single line sowing of *Ailanthus* was done along the outer edge of the *babul* and *khair* strip. This has been done with the object namely that the pungent and offensive odour of *Ailanthus* leaves and stems will change the mind of animals against making an entry into the plantation area. It is expected that at the end of the second growing season the dense hedge of *babul* and *khair* will be over 10 feet in height and get strong enough to offer effective physical resistance to animals. The fence-posts with the barbed-wire and staples can then be safely removed for use in the other plantations. All fence-posts were charred before fixing them in the ground. In November 1953 the height of the tallest plants of *babul* measured 60 inches.

The total cost on erecting the barbed wire-cum-stockade fencing amounts to Rs. 7,016 of which a sum of Rs. 4,295 was spent on the purchase and carriage of barbed-wire, staples and 3 inches long wire-nails and the remaining Rs. 2,721 were spent on labour employed on the preparation, carriage and fixing of fence-posts and also stretching and fixing of the barbed-wire

Cedrela toona, at the end of the first growing season.

and stockade. This works out to about Rs. 12 per chain or Rs. 9 per acre excluding the cost incurred on the purchase and carriage of the barbed-wire, etc. Experience shows that barbed-wire and staples last for about 12 to 15 years. This material will thus be useful for at least 6 different plantations of 300 acres each, assuming that the fencing will be removed at the end of the second growing season. The cost of the material debitable to this plantation, therefore, comes to Rs. 3 per chain or Rs. 2 per acre. The total cost of the fencing, therefore, amounts to Rs. 15 per chain or Rs. 11 per acre. So far the animal damage in the plantation lines is conspicuously absent.

Choice of species—The following furniture wood, plywood, matchwood and bobbinwood species were sown :—

1. *Shisham* .. *Dalbergia sissoo*
2. *Toon* .. *Cedrela toona*
3. *Semal* .. *Salmalia malabaricum*
4. *Bhurkul* .. *Hymenodictyon excelsum*
5. *Siris* .. *Albizzia procera* and *Albizzia lebbek*
6. *Arru* .. *Ailanthus excelsa.*

Jamun, *gutel*, *Acrocarpus fraxinifolius* and *Chickrassia tabularis* were sown as subsidiary species particularly in the low-lying areas. The seeds of all these species were collected locally except those of *Acrocarpus fraxinifolius* and *Chickrassia tabularis* which were indented from Bengal. The cost of collection of seed is Rs. 6 per acre, the most expensive collection being of *semal* seed done at Rs. 80 per maund, while *shisham*, *toon* and *bhurkul* cost, on an average, about Rs. 10 to Rs. 15 per maund.

Plantation technique—It was decided to raise the crops in mixtures consisting of three species only, as a happy mean between an intimate mixture of several species and a pure crop of one single species, to avoid the obvious risk entailed by either of the above extremes. The capacity of this soil to grow *shisham* and *toon* is evident from the fine growth these species are putting on in the 12- and 14-year old plantations. A mixture of *shisham* and *toon* has, therefore, been sown as a single line sowing in the middle of the worked strip over the entire 300-acre plot. *Semal*, *bhurkul*, *siris* and *Ailanthus* have been sown in blocks only, 4 contiguous strips forming a one acre block. The first four strips in a sub-plot were sown with *semal*, next four strips with *bhurkul*, next four strips with *siris* and next four strips with *Ailanthus* and so on. *Semal*, *bhurkul*, *siris* and *Ailanthus* have, therefore, been sown as block mixtures in blocks of one acre each.

By taking four adjacent strips to form a block of one acre each, a foolproof method was evolved avoiding all complications arising by following the chessboard square pattern. Seed sowing was started from 22nd May and concluded on 2nd June 1953. The labour charges engaged on sowing amounted to about Rs. 3 per acre.

Germination—The first shower of the good soaking rain fell on 24th June 1953. *Semal*, *bhurkul* and *toon* germinated completely within 5 days after the fall of the first shower of rain. By about 7th July the germination of all the species including that of *shisham* and *Ailanthus* was complete. By this time the regular monsoon had set in and there were good showers almost every day. The germination was so uniformly excellent that every inch of the sown line was completely covered with seedlings. It then became evidently definite that the spare seed in the store and the one year old nursery stock of *semal*, *bhurkul* and *toon* in the nursery beds reserved for re-sowing and gap filling were no longer required for this plantation.

Tending—The first tending operation started virtually with the germination of seed. The tiny young seedlings of weeds and grasses were pulled out by roots as they appeared on

the ground. If the weeds and grasses are allowed to develop their root systems before pulling them out the neighbouring seedlings of tree species are likely to be damaged by the pulling out of the weeds. Moreover, the earlier root completion is removed the better it is. The third advantage lies in the reduced cost of the operation if carried out at an early state.

Another very useful operation the usefulness of which is impossible to overemphasise is the spacing out of seedlings to relieve congestion, virtually from the very day they make their appearance above the ground. It is a fallacy to think that this operation should be postponed to the second year, on the ground that the seedlings being tiny in the first year are liable to be killed by frost, drought and damping off or suppressed by weeds, etc., and that as many seedlings as possible should be retained to make good the loss by mortality during the first year of the plantation. It, in fact, works the other way round. One well spaced seedling, however, small in size it be, withstands frost, drought, damping off or, for that matter any calamity, much better than many seedlings growing congested. This operation combined with the pulling out of weeds was concluded by the end of July 1953. The cost was Rs. 4 per acre.

By the end of August soil working with *khurpies* was started round the seedlings and this was continued up to the end of September. There was a spell of rainless period and the soil was in an ideal condition for hoeing with *khurpies*. The monsoon was at its tail-end and the soil did stand in need of aeration. This operation again combined with the spacing out of seedlings a second time was completed in the first week of October at a cost of Rs. 11 per acre. The last tending operation consisted of 6 inches deep hoeing in 18 to 24 inches wide strips on either side of the seedling lines with *pharwas* in October 1953 followed by the spacing out of seedlings for the third time in the season.

The details of the cost per acre up to the end of the first growing season, i.e., the actuals up to the end of November, 1953 are detailed below :—

		Rs.
(*i*)	Soil working (done entirely with hired tractors) ..	24
(*ii*)	Fencing (one sixth only of the cost of the material debited to this plantation)	11
(*iii*)	Collection of seed	6
(*iv*)	Sowing of seed	3
(*v*)	First weeding, including spacing out of seedlings in July 1953 ..	4
(*vi*)	Second weeding including spacing out of seedlings in September 1953	11
(*vii*)	6 inches deep hoeing in 18 to 24 inches wide strips on either side of the seedling lines with *pharwas* in October 1953 ..	5
(*viii*)	Last operation of the spacing out of seedlings by end of October 1953	2
(*ix*)	Miscellaneous, such as laying out of straight lines preliminary to tractor ploughing, digging drains for draining off excess water from the plantation area, fixing a hand pump in the centre of the plantation for drinking water for the labour and construction of *chappars* for the staff and for storing seed	8
(*x*)	Pay of Plantation Guards and watchers ..	Re. 1
	TOTAL ..	Rs. 75 per acre

The average daily wage of an adult male cooly was Re. 1 to Rs. 1/4/-. Labour is not easily available.

The height of the tallest plants measured in November 1953 in the plantation is :—

			inches
1.	*Shisham*	..	60
2.	*Toon*	..	43
3.	*Semal*	..	39
4.	*Bhurkul*	..	10
5.	*Siris*	..	34
6.	*Arru*	..	30

The success of this plantation, which is spectacular indeed is entirely due to the untiring efforts of Shri Amir Baksh, Forest Range Officer, Motipur Range. He deserves special commendation for the excellent work put in by him. On every item of work done in this plantation he was always ahead of the scheduled time.

DIPTEROCARPUS INDICUS, BEDD. (SYN. *D. TURBINATUS*, GAERTN. F.) ITS SILVICULTURE AND MANAGEMENT

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The systematic identity of the South Indian *Dipterocarpus indicus* has been somewhat in doubt. Biswas and Bole have grouped the Indian species under 3 sections of which this along with *D. turbinatus* has been placed under Section II, *Sphaerales*, Dyer. ; *D. indicus* is separated from *D. turbinatus* by the fact of its petioles being generally more than 1½ in. long and by its smaller leaves and flowers. The colour of the *flowers* of *D. turbinatus* is pink while that of *D. indicus* is white with a slight tinge of pink inside at times. Both Cooke and Talbot classify this species with *D. turbinatus*.

Description—Leaves : Ovate, 5 to 10 in. by 2½–7 in., secondary nerves 10–15 pairs. *Flowers* : Fragrant, about 3 in. in diameter, in axillary, 3 to 8 flowered racemes. *Calyx* : Tube obconic, hoary, pubererulous, the mouth contracted in fruit, the two enlarged lobes (wings) 5 in. long by 1 in. wide, obtuse, strongly 3 to 5-nerved and reticulately veined, the other lobes deltoid. *Petals* : White tinged with pink, linear, obtuse, twisted in bud. *Stamens* numerous, filaments yellow, linear subulate, terminated by a long slender bristle. *Fruit* : 1 in. in diameter, sub-globose (*Ind. For.*, April 1936, p. 2).

Local names—Bombay : *guva* ; Kanarese : *guga, challanne, dhuma* ; Coorg : *yennemara* ; Tamil : *ennai* ; Malayalam : *kakka, kalpayin, varangu* ; Travancore hills : *velayani, vavangu.*

Description—Dipterocarpus indicus is a lofty, evergreen resinous tree attaining heights of 150 ft. and girths of 14 ft. and over (Fig. 1). It develops a long, clean, straight cylindrical bole and an elevated round-headed crown which, in natural forest, stands generally well above the rest of the forest canopy. Bark is usually light-gray and smooth and sometimes exfoliates in irregular, rounded flakes.

Distribution and habitat—The tree abounds in evergreen forests from the southern ghats of North Kanara (Talbot) southwards all along the Western Ghats down to Travancore-Cochin (Fig. 2). It is common at Gersoppa, Agumbe and Bisle in Mysore, Makut in Coorg, Milkund Ghat, Tellichery, South Kanara, Wynaad and Tirunalvely of Madras and Shenkottah of Travancore-Cochin, up to a little over 3,000 ft., the most abundant growth being found between the altitudes 1,000 and 2,500 ft. The tree is confined to the tract lying between 9° and 15° N. – latitude and 74° and 77° E. – longitude. The climate in this region is humid. The absolute maximum shade temperature varies from 95° to 100°F. and the absolute minimum from 55° to 65°F. The annual rainfall varies from 100 to 350 in. or more. The daily and the annual variations of temperatures are moderate, but the rainfall during the different seasons of the year varies within wide limits. Most of the rain comes during the south-west monsoon which normally bursts early in June and continues till September ; during this period rainfall is heavy and frequent. The three months, from January to April, are the driest of the year. During the remaining months there are occasional showers.

Rock and Soil—The principal rock is Champion gneiss with hornblende schist, containing the minerals felspar, biotite, hornblende, black mica and garnet. Sometimes the Champion gneiss contains opalescent quartz. Reefs of ferruginous quartzite and quartz are common. Iron ore is occasionally found. Over the greater part of the area there is a bed of laterite which attains locally a thickness of 20 ft. or more and is probably a product of the ferruginous schist beds of the area.

The soil over a considerable portion of the tract which consists of hill slopes at high levels, is made up of ferruginous sandy loam (Mysore and Wynaad) or pale-red felspathic clay of moderate depth (N.- and S.-Mangalore) or red loam (Coorg). The presence of surface boulders makes the ferruginous loam frequently shallow but often it is 10 ft. deep. In valleys it is deeper. On scoured stream-banks loose, rounded pebbles are often seen to be held by a matrix of soil. In valleys the soil consists of gravelly loam redeposited from elsewhere, and of lateritic and granitic composition, very rich in humus, the layer of decaying vegetable mould being often 3 in. and more deep. The drainage is always good as the topography of the country is very irregular and the lateritic sub-soil is vescicular and porous.

Forest types and associate tree species—The tree is endemic in the "Western Tropical Evergreen" forest type (Champions 1*a*/C3). The following associate species of *Dipterocarpus indicus* are found in some typical localities :—

(1) *Linear Increment Plot No. 2*, Kanara Eastern division, Bombay—*Calophyllum elatum, Aglaia roxburghiana, Cinnamomum zeylanicum, Diospyros candolleana, Holigarna arnottiana, H. grahamii, Hopea wightiana, Lophopetalum wightianum, Mastixia arborea, Nephelium longana* and others. [G. S. Mathauda ; *Ind. For. Bull.* No. 169 (n.s.) Silviculture, 1953 ; pp. 10–21].

(2) *Linear Increment Plot*, Agumbe, Mysore State. The top storey of the forest contains *Calophyllum elatum, Poeciloneuron indicum, Mastixia arborea, Litsea wightiana, Dichopsis elliptica, Mesua ferrea* and *Canarium strictum*. (K. Kadambi, *Mysore Forest Journal*, October 1940, p. 3).

(3) *Bisle State Forest, Hassan district—Dipterocarpus – Vateria* association, with *Dipterocarpus indicus* and *Vateria indica* as the principal trees (Fig. 3) and *Kingiodendron pinnatum, Mesua ferrea* and *Calophyllum elatum* as its associates. (K. Kadambi, *Ind. For.* April 1939, p. 195).

(4) *Windward valleys* of the *Western Ghats* of *Hassan division*. *Palaquinum – Dipterocarpus* association, with *Palaquinum ellipticum* and *Dipterocarpus indicus*. There are a host of associates, prominent among them being *Hopea wightiana, Mesua ferrea, Kingiodendron pinnatum, Schleichera trijuga* and several others. (K. Kadambi, *Ind. For.*, Feb. 1950, p. 7).

(5) *Evergreen shola forests of South Coorg* :—

(*i*) *Vateria* type, with *Dipterocarpus indicus* and *Kingiodendron pinnatum* as auxiliary species.

(*ii*) *Dipterocarpus – Kingiodendron* type, with *Calophyllum* and *Dichopsis* as auxiliary species.

(*iii*) *Calophyllum – Dipterocarpus* type with *Kingiodendron, Mesua* and *Palaquium* as auxiliary species (Van Haeften, Working Plan).

(6) *Wynaad Ghat forests, Madras, shola type* : Important trees—*Calophyllum elatum, C. tomentosum, Artocarpus hirsuta* and *integrifolia, Dysoxylum malabaricum, Dipterocarpus indicus, Kingiodendron pinnatum, Elaeocarpus* (2 sp.), *Holigarna* (2 sp.) and several others. (A. N. Sarma's Working Plan, p. 6).

(7) *Shencottah division*, Travancore-Cochin—Top storey of evergreen forest contains : *Hopea parviflora, Cullenia excelsa, Dipterocarpus indicus, Dichopsis elliptica, Machilus macrantha, Mesua ferrea, Calophyllum tomentosum, Dysoxylum* (2 sp.), *Vateria indica* and several others. (M. N. Menon's Working Plan, pp. 11–12).

Leaf shedding, flowering and fruiting—The tree is typically evergreen, but owing to the great differences in the moisture conditions prevailing between the wet and the dry seasons

the density of the leaf cover varies greatly in the different seasons, and the onset of the dry season is foreboded by a heavy shedding of the old leaves, which reaches its climax during February–March ; the tree crowns are, therefore, provided with the lightest cover at this time. Fresh leaf appears abundantly in April and May.

The flowers appear during December and last till March. The height of flowering is in January and early February. (Kadambi, K., *Ind. For.*, March 1950, p. 8 ; Sarma, A. N., *W. Plan* of *Wynaad Ghat forests*, p. 10).

The fruit ripens in May and June. It is large (*Ind. For.*, Nov. 1936, p. 2) and has two wings each about 4 to 5 in. long. About 78 fruits weigh 1 lb. (Sen Gupta, 1937).

Seed—Germination and post – seedling stages—Germination is hypogeous, and the fleshy cotyledons remain within the fruit. The radicle appears from between the wings and curves rapidly downwards. The petioles of the cotyledons develop in the meantime and the plumule emerges from in-between them. The tap root is thick, woody, long and tapering with a few fibrous lateral roots. The petiole of the cotyledons is 1 to 1½ in. long and the lamina 1 in. long, obovate and fleshy. The stem is erect and woody and the young parts are tomentose with stellate hairs. The first internode between the cotyledons and the first pair of foliage leaves is 5 to 7 in. long and the subsequent ones ½ to 1 in. The first pair of leaves are opposite, subsequent ones alternate ; stipules are about ½ in. long, caducous.

Silvicultural characters—The tree is shade – tolerant, at any rate in its younger stages, and as the forests in which it thrives are dense its existence in them depends more or less upon this character. Its seedlings are capable of starting their life even in the densest shade, persisting for an indefinite period in it and pushing their way up, though slowly, inspite of the shade. Experiments done at Chandanatode and Topslip (Madras) to find the effect of 3 different intensities of shading namely – no shade, 50% shade and 100% shade at 3 ft. height during the rainless season (November to May) showed that shade is beneficial in preventing casualties. (*Silv. Res. Rpt.*, Mad., 1939–40).

Once established, the sapling can make sufficient progress only if it gets adequate light. Otherwise its growth stagnates, but unlike a typical light demanding species it does not die off in shade. With increasing altitude the demand for light also increases.

The tree thrives best in the damp, rich soil of the tropical rainforest charged with vegetable mould, teeming with decomposing bacteria and ventilated by a host of earthworms. The tree is sensitive to fire, its thin bark being ill-adapted to withstand the injury ; if the damage from fire exceeds slight, superficial scorching the trees are killed outright. The coppicing power of the tree is quite poor and generally, trees over 3 ft. in girth fail to coppice.

An interesting fact, and one of far reaching importance connected with management of this tree in the Agumbe–Kilandur forest zone, which is one of the richest *Dipterocarpus* areas of Mysore, is the fact that the growing stock of *Dipterocarpus indicus* is relatively poor in the intermediate diameter classes. The majority of the trees met with by the marking officer have reached the exploitable girth and there is also a fair abundance of young growth which has yet to reach the pole stage, but trees of the medium diameter classes are comparatively few. The abundance of seedlings and saplings, at which stage the trees are shade tolerant, is easy to understand. But, for advancing from the sapling to the pole stage the tree demands light, and in its absence or paucity its saplings are left behind in growth by those of the more hardy *Poeciloneron indicum* and *Mesua ferrea*. Where, however, a bunch of *Dipterocarpus* seedlings accidentally find themselves in an opening they shoot up, developing perfectly straight and cylindrical boles to a height of a hundred feet or more and, once at the top their crowns spread

laterally to assume the shape of an umbrella (Fig. 4). The shade bearing, thin cuticled leaf of the sapling is replaced in the region of the tree-crowns by thick cuticled, tough ones with sunken stomata. This is to be expected, since the microclimatic conditions prevailing inside the forest are markedly different from those in the region of the tree crowns where the scorching sun plays directly on the foliage.

The tree is sporadic to semi-gregarious, solitary giants towering well above the rest of the forest canopy and standing high are common (Fig. 4), but again patches consisting of half a dozen or more trees standing in close proximity to one another are also frequently met with (Fig. 5). The tree has, thus a strong tendency to come up in groups when there is an opportunity, though such groups are never quite pure and are often quite diffuse. This is most probably the result of the keen competition for space and light among the trees of the evergreen forest.

Regeneration, natural and artificial—The tree regenerates itself freely in nature. In felled areas, where the canopy has been disturbed and the soil wounded, regeneration is often copious. Quadrat counts of fully established seedlings done during 1934 in the Agumbe and Balehalli forests of Mysore, in a locality where the canopy had been slightly disturbed as a result of timber fellings gave the following results :—

Dipterocarpus indicus, natural reproduction counts in 6 ft. quadrats.

Number of seedings counted of important tree species

Quadrat No.	*Dipterocarpus indicus*	*Poeciloneron indicum*	*Mesua ferrea*	*Hopea parviflora*	Others
1	16	12	6	2	51
2	14	16	2	4	49
3	11	22	0	0	60
4	18	7	4	2	36
5	8	29	14	6	22
6	4	14	2	1	56
7	9	6	6	2	26
8	12	24	3	4	52
9	6	4	2	2	27
10	8	15	3	2	44

A clear germinating bed provided by the absence of leaf litter and well drained soil not subjected to bad aeration are the essential requirements of germinating seedlings. Under natural forest conditions the seeds of *Dipterocarpus indicus* do not retain their viability for more than a week or ten days and unless seed fall is quickly accompanied by the monsoon rains natural reproduction fails ; in favourable years when the pre-monsoon and monsoon rains are both timely and adequate germination is copious but the seedlings die out unless their root system comes in contact with mineral soil which process, however, is hindered in the evergreen forest on account of the heavy layer of detritus covering the forest floor.

In areas subjected to heavy exploitation the ingress of light assists in the rapid disintegration of litter, while at the same time the mechanical wounding of the soil during the felling and extraction operations exposes the mineral soil. In favourable seed years, therefore, elephant drag-paths and interior cart-tracks are often packed with seedlings. A

good number of these perish during the ensuing dry season, but many do survive and persist in the shade of the annuals which rapidly settle down in such places and serve to nurse the seedlings of the evergreen tree species. Excessive weed growth, however, smothers the tree seedlings and often kills them outright.

Experiments in the Ghat forests of Coorg to examine the effects of various manipulations of the upper and lower storey of the forest on the development of advance growth have indicated that a heavy opening of the upper canopy accompanied by adequate cleanings is probably the correct procedure. The most satisfactory development is obtained where only the top canopy trees are retained by removing the middle storey canopy, and under the conditions obtaining in Coorg the optimum number of top canopy trees to be retained seems to be about 30 to 40.

The most suitable method of securing the regeneration of *Dipterocarpus* and, in fact, of regenerating the valuable species of tropical evergreen forests in general, seems to be therefore the following :—

Stage (1).—Selection fellings of trees with a view to disturb the over-head canopy, and to *induce* natural regeneration. About 30 to 40 trees of the top canopy should be left per acre.

Stage (2).—Complete removal of the lower storey trees and undergrowth to admit chequered sunlight to the soil.

Stage (3).—Felling the remaining top storey trees to give complete overhead freedom to the young saplings, after they are fully established.

The tree can be raised by direct sowing or by planting out entire seedlings. (*Silv. Res. Rpt.*, Madras, 1946–47). Stump planting is not a satisfactory method though in Bengal stump planting is considered to be a satisfactory method of regenerating *D. turbinatus* which is closely allied to this tree (Homfray) and in one instance in Coorg, 50 per cent of the stumps of *D. indicus* planted were successful (Laurie). Top canopy shade is useful until the plants are fully established, and it is, therefore, best to sow seed or plant seedlings in natural forests after removing all the middle storey of the forest. Burning is not advantageous. "Notching"* the seed can also be done with advantage.

In Coorg, the species has been successfully introduced in abandoned *kumries* of deciduous ghat forests but some shade has been found essential in the early stages until the tree is well established. The plants in the *kumries* attained a height of 12 ft. in 7 years (*Silv. Res. Rpt.*, Coorg, 1923–24).

In Nilumbur, Madras (elevation 150 ft., rainfall 120 in.) transplanting nursery stock 6 months old under open canopy gave 73% survivals in the first year but this was reduced to 33% in the next year, a large number of seedlings having perished over the summer.

Dipterocarpus indicus seed retains its viability much better than the other species of *Dipterocarpus* (Champion). The seed can be stored up to one month in gunny bag, but deteriorates rapidly thereafter. The maximum germinative capacity obtained in Madras is 41% and the plant per cent 26 (*Silv. Res. Rpt.* Madras, 1938–39, 39–40). Nursery seedlings can be transplanted when 3 months old, but seedlings one-year old appear to be more suitable to plant. The best time for planting in Karianshola, Madras, was found to be August. In Bengal, transplanting of seedlings which were sown in the same year have been found very suitable for *D. turbinatus*.

* The word 'Notching' comes from Bengal. It is a process by which a hole is made in the ground with the point of a *dao* (a sharp instrument of Bengal) placing the seed in the hole and covering up the seed with earth with only the wings remaining exposed.

FIG. 1.

FIG. 3.

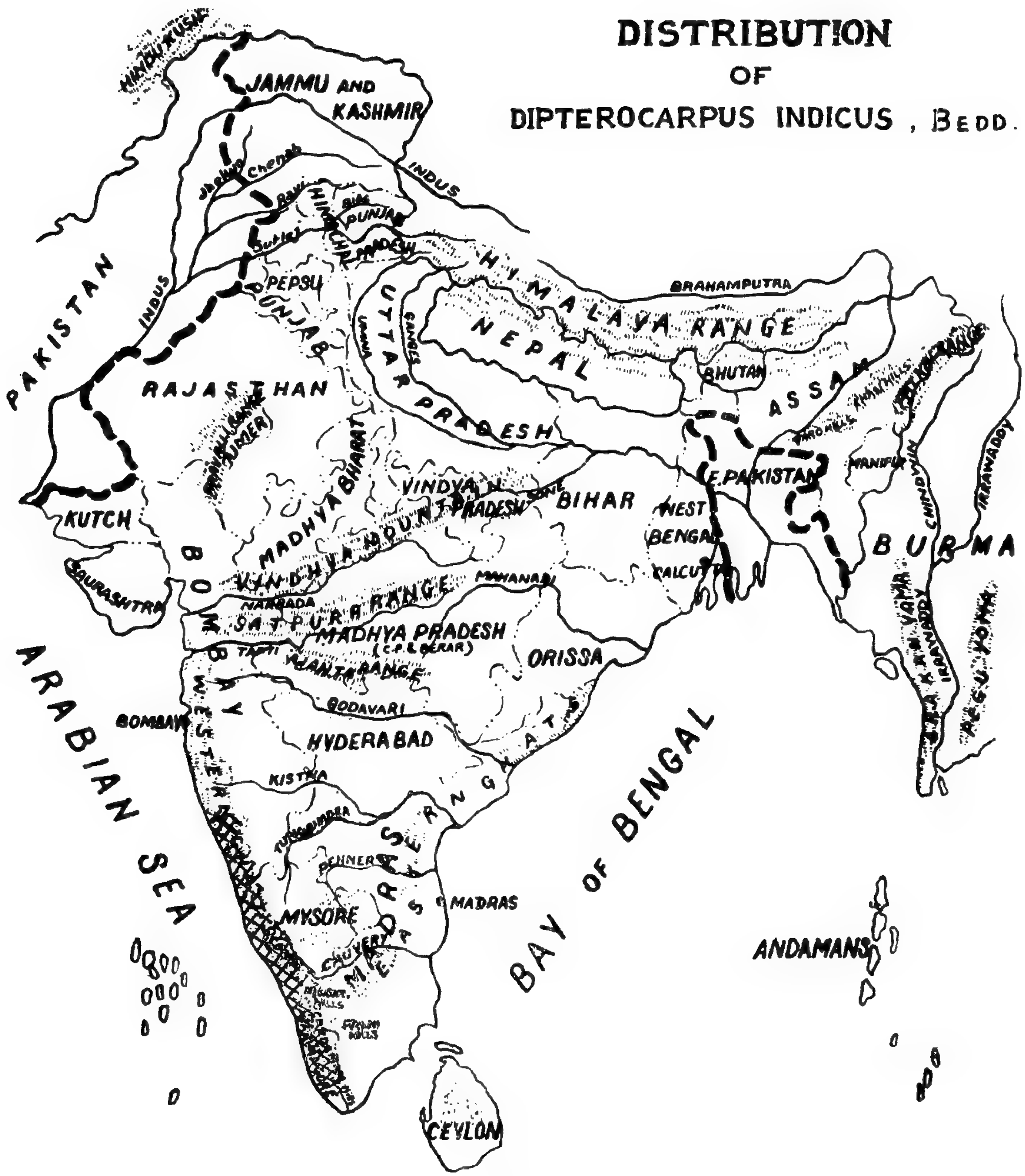
DISTRIBUTION
OF
DIPTEROCARPUS INDICUS, BEDD.
JAMMU AND KASHMIR
PAKISTAN
INDUS
RAJASTHAN
PUNJAB
PEPSU
UTTAR PRADESH
NEPAL
HIMALAYA RANGE
BRAHAMPUTRA
BHUTAN
ASSAM
E. PAKISTAN
BIHAR
WEST BENGAL
CALCUTTA
MANIPUR
BURMA
IRRAWADDY
CHINDWIN
KUTCH
SOURASHTRA
BOMBAY
MADHYA BHARAT
VINDHYA PRADESH
VINDHYA MOUNT
VINDHYA RANGE
NARBADA
SATPURA RANGE
MADHYA PRADESH
(C.P. & BERAR)
TAPTI
MAHANADI
ORISSA
GODAVARI
HYDERABAD
KISTNA
MYSORE
MADRAS
CAUVERY
CEYLON
ARABIAN SEA
BAY OF BENGAL
ANDAMANS

FIG. 2.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 7.

Seeds of *D. indicus* should be collected in May or June, as soon as they begin to fall, and sown immediately thereafter. They should be collected daily from the ground which has been previously cleaned under the mother trees to receive the seed fall. The seed is liable to the attack of a grub *Alicides crassus*, the presence of which can be recognized from a blob of gum visible on the seed. All such seeds should be rejected and only plump and heavy seeds should be sown 6 in. apart. In Chandanatode nursery, Madras, sowing the seed with the wings vertical, i.e., sticking out of the soil (Fig. 7), has proved less satisfactory than sowing them with the wings lying flat on the ground, because the radicle can then reach the soil when it is shorter. Sowing the seeds with their apex downwards after clipping their wings and burying the fruit to ⅓ of its length in the soil is stated to be the best. A layer of soil, about as thick as the thinnest diameter of the seed, is covered over the seeds during sowing. Shading the beds is advantageous.

Methods of management—In Mysore State, where the tree has been systematically exploited almost since the twenties of this century for preparing railway sleepers and floor-boards of railway carriages, the tree is worked under the 'Selection' method with an exploitable girth of 8 ft., which was raised to 8½ ft. some time ago ; 33 per cent of the exploitable trees are reserved to offset the deficiency of stems in the lower diameter classes.

In the felled areas, where natural reproduction is abundant if not copious, the regeneration is tended and encouraged to progress by "lifting" the canopy in three stages called : (A) the *Initial* stage, (B) the *Intermediate* stage, (C) the *Final* stage. In the *Initial* stage all the undergrowth of the forest except the seedlings, saplings and poles of the 'elite' species among which *Dipterocarpus indicus* is one, is cut away. Climbers and other unwanted growth are also removed. In the *Intermediate* stage, removal is done of the middle layers of the forest canopy, of saplings and poles of unwanted species and miscellaneous growth. In the *Final* stage all stems of the elite species, of and above the exploitable sizes found in the overwood are cut. (Kadambi, *Working Plan*, 1941–61).

In Coorg, the evergreen ghat forests containing *Dipterocarpus indicus* have been worked according to Van Haeften's plan partly under the "Irregular Shelterwood" and partly under the "Selection" methods. Under the former method all trees of and above 4½ ft. in girth are felled, those under this girth being considered as part of the regeneration. These fellings are accompanied in the following year by what are called "rubbish fellings" in which all unmarketable trees 4½ ft. and over in girth interfering or likely to interfere with trees of the valuable species are removed. In the areas worked under the "Selection" method, all marketable trees of exploitable size, fixed at 6 ft., are first removed and this is followed by heavy "Improvement" fellings covering the unmarketables, with a view to tend poles of the valuable species.

External dangers—The damage to seed by the grub of *Alcides crassus* Pasc, has already been referred to. Probably there are also other kinds of moth larvae which damage the seed. The fruit body is presumably infected while young and the growth of the larvae goes on with the growth of the fruit until the infected fruit is composed merely of the outer shell. This causes the fruit to fall before it is mature. A shoot borer attacks the seedlings and saplings of *Dipterocarpus indicus* but the plant is not killed outright ; only the top portion dies and a lateral shoot replaces it. Sometimes the leading shoots are browsed by deer but damage from this source is insignificant.

Rate of growth—Moderately fast under favourable conditions ; 1st year : ¾ ft., 2nd year : 2 ft., 3rd year : 3½ ft., 4th year : 5 ft., 5th year : 7 ft. (Sen Gupta). Inadequate or poor light conditions, however, cause severe stagnation of growth, and the growth figures recorded

by various observers are not therefore uniform. In Coorg, raised in abandoned *kumris* of deciduous ghat forests, the plants attained a height of 12 ft. in 7 years (Champion's tour notes, 1927–28). In the natural regeneration plots laid out in February, 1925 where 70 to 100 trees of the top canopy were left per acre and all the middle and lower storey trees were cut, the average height of selected plants progressed from 6 ft. 11 in. in February 1925 to 8 ft. 5 in. in January 1927. (*Adm. Rpt.* Coorg, 1927).

In the "Natural Regneration Tending" plot at Agumbe, Mysore State, the following heights have been recorded. The saplings were under the shade of the evergreen forest cover, and the rate of height growth is, therefore slow. The age of the plants is not known :—

Dipterocarpus indicus—Height growth of natural seedlings and saplings growing in dense shade

Date of measurement											
28–5–38		13–8–38		28–11–38		27–4–39		May 1940		May 1941	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
7	2	7	3½	7	4	7	4½	7	5	7	6
10	2	10	7½	10	8	10	8½	10	9	10	11
16	8	16	8	16	10	16	11	17	0	17	2
2	2	2	3	2	4	2	5	2	5	3	4
5	5	5	6	5	7	5	8	5	8	5	8
3	5	3	6½	3	8	3	9	3	9	4	0
5	1	7	7	7	4	7	4½	7	5	8	2
7	0	5	1½	5	2	5	2	5	3	5	6
6	1	6	6	6	10	6	0	6	11	7	0
7	2	7	6	7	6	7	6	7	7	8	9
8	3	8	5½	8	6	8	7	8	9	9	0
15	6	16	4	16	4½	16	9	17	2	18	0
1	2	1	3	1	3	1	7	2	0	2	5
2	11	3	3½	3	5	3	6	3	6	4	0
4	0	4	1½	4	1½	4	2	4	2	4	5
13	2	13	4	13	5	13	5	13	6	14	0
7	8	7	9	7	10	7	10	8	0	8	2
1	9	1	9½	2	0	2	1	2	5	2	10
2	10	2	11	3	0	3	1	3	2	4	0
7	0	7	2	7	2½	7	3	7	4	8	4

In Karianshola experimental garden, Madras, plants from sowings done in 1939 under the top canopy of evergreen forest attained a mean height of 14·6 in. in 4 years. In nursery beds, heights of 17 in. to 18 in. have been recorded for one-year old plants raised from seed. (*Silv. Res. Rpt.,* Madras, 1942–43, p. 54 and 1939–40).

The following height increments have been recorded in Wynaad (Madras) for natural seedlings growing under top canopy cover. The plot was thinned in 1950 leaving only the best plants.

Dipterocarpus indicus—Height growth of seedlings of known age

Year of measurement	Age in years	Survival %	Mean height ft.	Mean height in.	Increment (annual) ft.
1937	2½	100	1	10·24	..
1938	3½	100	2	6·31	0·66
1939	4½	100	3	9	1·23
1940	5½	100	5	6	1·30
1941	6½	100	6	5	1·38
1942	7½	100	8	11	2·47
1943	8½	100	10	11	1·99
1944	9½	97	12	10	1·90
1945	10½	97	13	11	1·14
1946	11½	97	15	11	1·98
1947	12½	97	17	1	1·14
1948	13½	93	19	1	2·05
1949	14½	93	19	8	0·57
1950	15½	32	23	9	4·08
1951	16½	32	24	6	0·74

Girth increment—The following girth increment of sample trees have been recorded by Van Haeften in the sample plots of Coorg :—

Dipterocarpus indicus—Girth increment of trees in Makut Range

GIRTHS								Girth increment per year
1924		1927		1934		1937		
ft.	in.	ft.	in.	ft.	in.	ft.	in.	in.
1	3	..		2	3½	2	4½	0·34
4	5	4	11¾	7	8	7	9¾	2·8
4	5	5	1	5	4	..		0·34
5	6	..		7	4¾	7	7	0·75
5	6	6	3¾	6	11	..		0·8
5	6	6	4	6	8¾	6	9⅞	0·5
6	7	6	8	7	11½	..		1·7

The following current annual girth increments have been recorded for the tree in Shimoga Division, Mysore State.

Dipterocarpus indicus—Rate of girth increment in Agumbe Range

Girth classes in.	C.A.I. of girth in.
18–36	0·37
72–90	0·25
Over 90	0·25

The following information of the rate of diameter growth is based on data collected from the Linear Tree Increment Plot Nos. 1 and 2 of E.D. Kanara, and Nos. 1 and 2 of W.D. Kanara, Bombay State—(*Ind. For. Bull.* (n.s.) Silviculture, 1953, No. 169, pp. 8–9).

Dipterocarpus indicus—Rate of diameter growth

Age counting from 7 in. d.b.h. stage (years)	Diameter at breast height in.
10	7·7
20	8·4
30	9·2
40	10·0
50	10·8
60	11·8
70	12·7
80	13·7
90	14·7
100	15·7
110	16·7
120	17·7
130	18·8
140	19·8
150	20·9
160	22·0
170	23·2
180	24·4
190	25·6
200	26·8
210	28·0

The following time was taken by the tree to cross the 2 in. diameter classes—(*Ind. For. Bull.* (n.s.) Silviculture, No. 169, 1953).

Dipterocarpus indicus—Time taken to cross the different diameter classes

Diameter class in.	No. of years required to cross the diameter classes
8–10	25
10–12	22
12–14	21
14–16	20
16–18	20
18–20	19
20–22	18
22–24	17
24–26	17
26–28	16

Commercial Volume figures—The yield of commercial timber per tree in the ghat forests of Coorg has been recorded by Van Haeften as below :—

Dipterocarpus indicus—Yield of timber from different girth classes

	Girth classes in feet					
	6–7	7–8	8–9	9–10	10 and above	Kerti coupe No.
Average volume per tree in c.ft.	63	166	159	216	291	III
Do.	72	112	146	137	195	IV
Do.	82	114	173	194	236	V
Do.	86	122	121	171	173	VI
Do.	109	143	132	212	242	VII

The following commercial volume figures are available for the species from the ghat forests of Shimoga and Sagar divisions, Mysore State—(*Working Plan,* 1941–61, p. 72).

Dipterocarpus indicus—Local commercial volume table showing the outturn of timber in the log fit for conversion into sleepers

Girth class at breast height ft.	No. of trees on which yield is based	Yield, round timber c.ft.
	Agumbe State Forest	
7– 8	191	76*
8– 9	628	156
9–10	524	213
10–11	462	250
11–12	334	285
12–13	297	321
13–14	196	347
14–15	124	390
15–16	67	414
16–17	39	523
17 and over	36	476†
	Balehalli State Forest	
8– 9	102	165
9–10	115	203
10–11	89	240
11–12	53	286
12–13	23	346
13–14	12	369
14–15	5	421

* Immature trees and therefore low output of timber fit for conversion into sleepers.

† Trees partly unsound and hence the fall in utilizable volume.

Utilization—The wood of *Dipterocarpus indicus* is finer textured and of a better quality than those of the other *Dipterocarpus* species. It is moderately heavy (Sp. Gr. = 0·78) nearly straight grained and light red to greyish brown in colour. It does not take good polish. The resin canals found in this wood are said to be smaller than those of the other common species of *Dipterocarpus*. Local variations of the size and abundance of these resin ducts has been observed in the ghat forests of Mysore, the ducts being more abundant in trees growing just at head of the ghats, where the tree also attains its best dimensions. Weight at 12 per cent moisture content 43 lb. per c.ft. (43, Jagadamba Prasad). Gamble, quoting Bourdillon, gives P. = 695.

The timber is moderately refractory to season. It is liable to split, and large size logs split badly on exposure to the sun. Green conversion and girdling give the best results (Pearson and Brown, I, 72).

The timber is not durable. Experiments done in Madras on felled timber left with bark and without bark showed that 6 species of *Cerambycidae* attack the wood. *Aeolesthes heloserícea* is a notorious borer of logs. At higher altitudes attack is less but at low altitudes it is heavy. Debarked logs are less attacked. Pinhole borers *Xyleborus* spp. attack the timber felled during the rains, more than that felled in October or April. The *Bostrichidae* (Powder post beetles) attack sapwood after it has started drying. August to November fellings are attacked most both in shade and in the open, but the attack is less in December fellings and absent in January to July fellings. Timber sawn immediately after felling is liable to serious *Bostrychid* beetle attack ; the attack is much less if the timber is left in the log form for 3 months or more before sawing. These observations hold good only for the localities where the tree actually grows. [*Ind. For. Bull.* No. 136, Entomology (New Series) 1947].

Among fungi, the sap staining fungus *Ceratostomella* discolours the wood left in the forest rapidly. Rot is more common in trees which have been tapped for wood oil.

The timber is not proof against termites. The wood can be treated with creosote and 'ascu'. Complete penetration is obtained with 6–7 lb. per c.ft. of the former preservative. Treated sleepers can be expected to last for 10 to 15 years.

The timber can be sawn and worked with ease.

Uses—The wood has been used extensively in Mysore State for over 25 years for railway sleepers, after treatment with 'ascu' or 'creosote'. About 4,000 tons of wood have been converted during some years, chiefly into sleepers and also into railway bottom boards. Other uses of the wood are for house construction as beams, scantlings, planking, ceiling and floor boards, ship building, masts and spars. It is a cabinet wood equal to the common types of mahogany. The wood is classed among the 'excellent' fuel woods, its calorific value being – sapwood : 5,170 calories, 9,307 B.t.u., and heartwood – 5,199 calories, 9,358 B.t.u. [Krisha and Ramaswamy, *Ind. For., Bull.* (n.s.) No. 79, 1932, 16 ; *Ind. For.* 1948, 279].

In Bombay the timber has been sold in competition with *Dipterocarpus turbinatus*, Gaertn. f. the well-known Gurjan wood of Burma.

Minor Forest Products—The tree can be tapped for oleoresin. Experiments made in this connection in the forests of Agumbe Range, Mysore, have shown that the blaze should be scraped every day to get a good yield. The oleoresin obtained from the tree, known as Dhuma oil in Mysore, is an opaque, grey fluid which, if left standing separates into 2 distinct layers, a viscid fluid dark reddish brown in colour at the top and a thick dingy white portion below. A sample of the oleoresin obtained from Mysore and tested at the Indian Institute of Science, Bangalore had the following constants :—

Acid val., 11·6 ; sap. val., 14·9. It contains about 67·8% of volatile matter. On steam distillation a colourless volatile oil with a characteristic resinous odour, a

faintly acid reaction and pungent taste was obtained. The oil has recently been found to contain both x– and B-caryophyllenes (*Science and Culture*, Vol. **16**, No. 2, Aug. 1950, pp. 74–75).

The resin is soluble in most organic solvents except petroleum, spirit and oil. Varnishes can be prepared out of it. (*Journal of the Indian Institute of Science*, 1918–20, 2, 37). The oleoresin is used against rheumatism. It is also used to adulterate dammar (Bourdillon, 32).

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LIST OF ILLUSTRATIONS

FIG. 1.—The bottom portion of a mature tree of *Dipterocarpus indicus*, showing its characteristic bark and the large size which the tree can attain in the tropical evergreen forests of the Western Ghats. girth at breast height 15 feet 4 inches, Balehalli State Forest, Shimoga division, Mysore State.

Photo—Author, June 1933.

FIG. 2.—Map showing the distribution of *Dipterocarpus indicus*, Bedd.

FIG. 3.—A tree in the *Dipterocarpus—Vateria* association, Windward valley, Bisle State Forest, Western Ghats of Hassan district, Mysore State—Height 122 feet, Girth 8 feet 10 inches. The other tree found on the extreme right is *Vateria indica*.

Photo—Author, Dec. 1942.

FIG. 4.—Crown photograph of a tree of *Didterocarpus indicus*, showing how this, the tallest tree of the evergreen forest unfurls its full foliage to the sun, Heggan, Tungabhadra State Forest, Mysore State.

Photo—Author, May 1940.

FIG. 5.—A group of half a dozen trees of *Dipterocarpus indicus*. The tree is semi-gregarious and is often found in more or less diffuse patches. Height of tallest tree, 152 feet, Agumbe Ghat, Mysore.

Photo—Author, Nov. 1929.

FIG. 6.—Natural reproduction of *Dipterocarpus indicus*, *Calophyllum tomentosum* and *Hopea parviflora* under shelterwood. The middle canopy layer has been removed and annual cleanings done for several years. Makut, Coorg.

Photo—H. G. Champion, March 1927.

FIG. 7.—Seed of *Dipterocarpus indicus* sown in nursery beds with wings pointing upwards, Chandanatode, Wynaad division, Madras.

Photo—M. V. Laurie, June 1934.

INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART XX.—CHEMICAL PULPS FROM *EUPATORIUM ODORATUM* LINN. (*ASSAM-LOTA*)

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SUMMARY

Laboratory experiments on the sulphate pulping of *Eupatorium odoratum* (*Assam-lota*) are described. *Assam-lota* is short-fibred. Taking into consideration the yields of bleached pulps obtained under conditions found best among those studied, the total quantities of chemicals required for digestion are high. The bleach requirement is very high. *Assam-lota* does not seem to be an economical fibrous raw material for the production of white writing and printing papers.

INTRODUCTION

Eupatorium odoratum Linn. (*Assam-lota*) is a shrub up to about 5 feet high. It belongs to the family Compositae. This weed is a pest in Assam. It occurs in the eastern sub-Himalayan plains and ascends the foothills with equal vigour, sometimes reaching an elevation of 10,000 feet[1]. This species also occurs in Bengal, Nepal, Bhutan, South Burma and Malaya. The growing menace of this plant is described by Sen Gupta[2]. This weed invades waste and fallow lands, pastures and forests that have suddenly been opened out with a sprinkling of canopy trees or none in the overwood. The plant being a strong light demander, its growth is kept in check by a close and dense canopy.

Assam-lota is a coarse, perennial, often straggling plant. Its winged seeds are carried by the wind far and wide during the months of February and March, when the ground is generally bare and burnt and, therefore, offers a suitable germinating bed to the species to regenerate itself profusely. Once it has spread out its roots, it can withstand adverse factors such as fire or grazing. The shoots are evergreen and succulent and have an unattractive odour.

At the instance of the Senior Conservator of Forests, Assam, an investigation was undertaken in this Institute to study the utilization of this plant for the production of pulps for writing and printing papers. The results are described in this bulletin.

THE RAW MATERIAL

The raw material (55 lb.) for this investigation was supplied by the Beat Officer, Dimapur Forest Beat, Assam, at the instance of the Senior Conservator of Forests, Assam. The supply consisted of stems and branches 3 feet to 4 feet 8 inches in length and 0·15 to 0·9 inch in diameter. The colour of the sticks was light brown. The moisture content of the material as received was about 7%.

PROXIMATE CHEMICAL ANALYSIS

The material with the bark on was crushed and cut. The dust made from these pieces was used for the proximate chemical analysis employing the TAPPI standard methods. The results are recorded in Table I.

TABLE I

Proximate chemical analysis of Eupatorium odoratum

		% on the oven-dry basis except moisture
1.	Moisture	6·80
2.	Ash	2·73
3.	Cold water solubility	15·00
4.	Hot water solubility	17·89
5.	1% NaOH solubility	31·00
6.	10% KOH solubility	45·50
7.	Ether solubility	1·19
8.	Alcohol-benzene solubility..	4·68
9.	Pentosans	16·59
10.	Lignin	24·98
11.	Cellulose (Cross and Bevan)	52·78

These results suggested that *Assam-lota* might be tested for suitability for writing and printing papers.

FIBRE DIMENSIONS

The crushed and cut material without removing the bark was digested by the sulphate process using 26% of chemicals ($NaOH : Na_2S = 2 : 1$) in 52 g./litre concentration at 153°C. for 6 hours. The pulp was bleached with bleaching powder and used for the determination of the length and diameter of the fibres. The results are given in Table II. The fibre length distribution is given in Table III and the fibre diameter distribution in Table IV.

TABLE II

Fibre length

	Fibre length mm.	Fibre diameter mm.
Minimum	0·29	0·0066
Maximum	2·28	0·0297
Average	0·73	0·0171

The ratio of the average fibre length to diameter = 43 : 1.

TABLE III

Fibre length distribution

Length of fibres mm.	Number of fibres	% of fibres
From 0·29 to 0·40	13	6·5
From 0·41 to 0·60	52	26·0
From 0·61 to 0·80	88	44·0
From 0·81 to 1·00	32	16·0
From 1·01 to 1·50	9	4·5
From 1·51 to 2·00	4	2·0
From 2·01 to 2·30	2	1·0
TOTAL	200	100·0

TABLE IV

Fibre diameter distribution

Fibre diameter mm.	Number of fibres	% of fibres
From 0·006 to 0·0120	7	3·5
From 0·0121 to 0·0180	68	34·0
From 0·0181 to 0·0240	114	57·0
From 0·0241 to 0·0300	11	5·5
TOTAL	200	100·0

PRODUCTION OF PULP

The material with the bark on was cut and digested by the sulphate process with 26% chemicals in 52 g./litre concentration at 162°C. for 6 hours. The pulp was not well-cooked. Therefore, the material was crushed between the rollers of the factory crusher and then cut into small lengths of about 1 inch. These crushed and cut pieces were used for the pulping experiments.

The digestions were carried out by the sulphate process using caustic soda and sodium sulphide in the ratio of 2 : 1. The quantities for cooking were varied from 22 to 26% (on the oven-dry basis of the raw material) and the temperature from 142° to 170°C. All the digestions were carried out for 6 hours ; this period included time required for raising the temperature from 100°C. to the cooking temperature. It took about 30 minutes for raising the temperature of the contents of the autoclave to 100°C. The material liquor ratio was 1 : 5.

TABLE V.—*Sulphate digestion of Eupatorium odoratum*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals* (NaOH : Na_2S=2 : 1)	Concentration of chemicals	Digestion temperature	Digestion period	Consumption of chemicals*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder containing 35% available chlorine*	Bleached pulp yield*
	%	g./litre	°C.	hours	%	%	%	%
1*a*	22	44	162	6	21·7	43·0	12·6	36·6
1*b*	22	44	162	6	21·7	43·0	13·5	37·0
2	24	48	142	6	23·9	47·8	..	..
3*a*	24	48	153	6	22·2	44·6	12·9	37·9
3*b*	24	48	153	6	22·2	44·6	14·7	37·9
4*a*	24	48	162	6	23·0	42·7	14·1	34·9
4*b*	24	48	162	6	23·0	42·7	14·6	36·4
5*a*	24	48	170	6	23·4	41·5	13·6	33·3
5*b*	24	48	170	6	23·4	41·5	14·5	33·5
6*a*	26	52	142	6	22·8	43·5	13·0	38·1
6*b*	26	52	142	6	22·8	43·5	13·8	38·8
7*a*	26	52	153	6	24·9	42·8	15·3	36·3

* The % is expressed on the basis of the raw material (oven-dry).

and strength properties of standard pulp sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 62°F.

10	11	12	13	14	15	16	17	18
Freeness of pulp	Basis weight	Breaking length (Schopper)	Stretch	Tear factor (Marx-Elmendorf)	Brust factor (Ashcroft)	Folding endurance (Schopper)	Brightness	REMARKS
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds		
310	60·0	8260	2·6	68·8	40·4	57	64	Well-cooked pulp was obtained. Intermediate alkali treatment was given during bleaching.
305	60·5	8520	2·8	69·9	40·7	81	63	No intermediate alkali treatment during bleaching.
..	..	..	..	..	..	..	..	The pulp was under-cooked and was not bleached.
308	59·0	8870	3·7	64·4	40·3	71	51	Well-cooked pulp was obtained. Intermediate alkali treatment was given during bleaching.
328	60·8	8650	3·0	65·8	40·0	77	49	No intermediate alkali treatment was given during bleaching.
276	62·0	7740	3·2	62·3	36·7	42	55	Well-cooked pulp. Intermediate alkali treatment was given during bleaching.
306	61·0	8130	3·2	64·3	42·1	72	53	No intermediate alkali treatment was given during bleaching.
315	61·9	7070	2·6	55·3	34·9	20	57	Well-cooked pulp. Intermediate alkali treatment was given during bleaching.
286	61·8	8230	3·0	56·2	40·4	51	48	No intermediate alkali treatment was given during bleaching.
299	60·7	8250	3·6	63·9	41·7	71	55	Well-cooked pulp. Intermediate alkali treatment was given during bleaching.
293	62·3	9410	4·0	68·2	44·0	120	50	No intermediate alkali treatment was given during bleaching.
286	60·4	6880	2·9	44·7	34·9	34	60	Well-cooked pulp. Intermediate alkali treatment was given during bleaching.

(*contd.*)

TABLE V.—*Sulphate digestion of Eupatorium odoratum*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals* (NaOH : Na_2S=2 : 1)	Concentration of chemicals	Digestion temperature	Digestion period	Consumption of chemicals*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder containing 35% available chlorine*	Bleached pulp yield*
	%	g./litre	°C.	hours	%	%	%	%
7b	26	52	153	6	24·9	42·8	17·0	38·3
8a	26	52	162	6	24·9	40·4	13·8	30·2
8b	26	52	162	6	24·9	40·4	14·4	32·4
9a	10 in the first stage and 18 in the second stage	20 in the first stage and 36 in the second stage	120 in the first stage and 150 in the second stage	2 in the first stage and 3 in the second stage	25·6	44·6	23·4	32·2
9b	,,	,,	,,	,,	25·6	44·6	23·4	33·9
10a	,,	,,	,,	2 in the first stage and 4 in the second stage	26·3	43·6	15·6	34·6
10b	,,	,,	,,	,,	26·3	43·6	16·0	37·1

* The % is expressed on the basis of the raw material (oven-dry).

and strength properties of standard pulp sheets—(concld.)

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 62°F.

10	11	12	13	14	15	16	17	18
Freeness of pulp	Basis weight	Breaking length (Schopper)	Stretch	Tear factor (Marx-Elmendorf)	Brust factor (Ashcroft)	Folding endurance (Schopper)	Brightness	REMARKS
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds		
301	60·9	7750	3·1	50·9	36·9	70	54	No intermediate alkali treatment was given during bleaching.
334	61·2	6890	3·1	56·0	35·0	40	57	Well-cooked pulp. Intermediate alkali treatment was given during bleaching.
315	60·8	7710	3·0	58·8	39·2	42	51	No intermediate alkali treatment was given during bleaching.
315	61·7	7130	2·8	55·1	34·4	45	54	In Serial Nos. 9 and 10, "fractional" method of digestion was employed. Only NaOH was used in the first stage of cooking. In Serial Nos. 9*a* and 10*a*, intermediate alkali treatment was used during bleaching, whereas no such treatment was used in Serial Nos. 9*b* and 10*b*. In Serial No. 9 under-cooked pulp was obtained. The pulp in Serial No. 10 was well-cooked.
334	61·7	7240	3·0	58·3	34·8	31	53	
305	61·2	7300	2·9	60·0	36·8	38	53	
295	60·8	7360	3·1	60·9	36·3	36	48	

The pulp was washed and bleached in two stages with bleaching powder, using about 75% of the total bleach in the first stage at 35°C. ; the second stage of the bleaching was carried out at the room temperature. In each case, the bleaching was also carried out with an intermediate alkali treatment using 2% caustic soda (on the oven-dry basis of the pulp) at 70°C. for 1 hour. The bleached pulp was beaten in the Lampen Mill and standard sheets were made on the sheet making machine recommended in the Second Report of the Pulp Evaluation Committee to the Technical Section of the Paper Makers' Association of Great Britain and Ireland (now known as the British Paper and Board Makers' Association). The standard pulp sheets were conditioned at 65% R.H. and 62°F. before test.

The digestion conditions, pulp yields, bleach consumption, strength properties and brightness of the standard pulp sheets are recorded in Table V. The brightness was determined using a Photoelectric Reflection Meter Model 610. As the digestion of the crushed and cut material with 22% chemicals at 142°C. and 153°C. for 6 hours yielded under-cooked pulps which were not processed further, the results of these experiments are not given in Table V.

Digestions were also carried out by the "fractional" or two-stage method. In the first stage, the cooking was carried out with caustic soda and in the second stage, a mixture of cuatic soda and sodium sulphide in the ratio of 2 : 1 was used. The results of these experiments are given in Table V (Serial Nos. 9 and 10).

DISCUSSION

The results recorded in Table V show that the bleach requirement is very high in the case of the pulps from *Eupatorium odoratum.* The bleached pulps have low brightness. The pulps in the majority of cases could not be bleached to a satisfactory whiteness even with excess of bleaching powder in quantities greater than those recorded in column 8, Table V. The bleach requirement increased with an increase in the quantity of chemicals used for cooking. Under the conditions studied, the digestion of the material with 22% chemicals at 162°C. for 6 hours gave the best results. The "fractional" or two-stage digestion method was not found to be better than the one-stage method.

CONCLUSIONS

1. Bleached pulps in 30·2–38·8% yield were obtained on pulping *Eupatorium odoratum* by the sulphate process. The requirements of chemicals for digestion and bleaching were high. In most of the cases, the bleached pulp was not quite white.

2. The average fibre length of the pulp was 0·73 mm.

3. The one-stage method of cooking gave better results than the "fractional" or two-stage method.

4. *Eupatorium odoratum* does not seem to be an economic fibrous raw material for the production of white writing and printing papers.

Thanks are given to the Senior Conservator of Forests, Assam, for supplying *Eupatorium odoratum* for this investigation.

REFERENCES

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2. Sen Gupta, J. N. *The Indian Forester*, 1949, **75**, No. 9, 351.

Shri C. R. Ranganathan (President, F.R.I. and Colleges) delivering his address of welcome to Shri Rajyapal Munshi. 31-3-1954.

CONVOCATION DAY OF THE INDIAN FOREST COLLEGE
AND THE
INDIAN FOREST RANGER COLLEGE, DEHRA DUN, 1954

The ceremonial close of the 1952–54 Indian Forest College and Indian Forest Ranger College courses took place on 31st March 1954 in the Convocation Hall of the Forest Research Institute. Shri Rajyapal K. M. Munshi delivered the Convocation Address and presided at the distribution of prizes, diplomas and certificates which he gave to the students after the following address. He also awarded the four All-India *Vana Mahotsava* Shields for 1951 and the Howard Medals for 1952 and 1953 to their respective winners.

Shri Rajyapal said :

"I am obliged to my friend, Dr. Deshmukh, to invite me to deliver the Convocation Address of the Forest Research Institute in place of His Highness, the Jam Saheb, who could not come on account of slight indisposition.

"My associations with the Forest Research Institute are so close that I could not resist the temptation of meeting you all, particularly when this is an occasion when my friend, Shri Chaturvedi, will be in office as the Inspector-General of Forests, perhaps for the last time. As you know, it was his advice and experience that enabled me in 1950–52 to convert forestry, the Cinderella of the Central Ministry of Agriculture, into an independent princess in her own right. To the students who are going out to-day, therefore, I cannot give a better send-off than to say that they should keep before them throughout their life, as an ideal, the work and achievements of Shri Chaturvedi. And I can assure you that if, during the last four years, forestry and tree-planting have come to occupy a high position in the country's life, it is due to his indefatigable enthusiasm.

"The Forest Research Institute, under your able Director, has borne the burden of the new movement. The Institute has a great future before it. The training which the Institute gives creates *esprit de corps* among the foresters and results in developing that uniform outlook on forest policy and forest technique which is so essential to the development of the country.

"Forests, under our Constitution, are primarily the responsibility of the States. It is all the more necessary that forest officers all over the country should have a uniformly vigorous outlook ; for our forests play a tremendous part in maintaining those environmental features which have dictated our political boundaries, determined our social movements and developed our cultural heritage as well as the social and economic life on which our destiny depends.

"I am sure you know all about *Vana Mahotsavas* and what they have achieved. On this occasion therefore, I will charge you with the responsibility of becoming its missionaries.

"There has been much ill-advised criticism of this national festival. You will have, when going about your work, to face this criticism. Don't be misled by it. Its object is to revive tree-consciousness in our minds as a nation and to translate it effectively into action. In this connection I may refer you to the wise words of Dr. Deshmukh : 'Our detractors scoff at the edifying spectacle of boys and girls planting trees ; they look askance at the men who matter giving a lead in the noble task. These critics are generally more interested in the number of plants which die and not in those which survive. It is not sufficiently realized that the value of a movement like this cannot be judged in a year or two. What matters, after all, is not the number of trees planted but the inculcation of the habit of planting trees among the people. Of course, we must always try to do our best to see that the trouble we take in planting is not allowed to come to nothing by any lack of care after planting'.

"How this *Vana Mahotsava* became a part of me defies analysis.

"In May 1950, when on my way to Bombay, I began to write my first official speech as a Minister, I had only a preliminary talk with Shri Chaturvedi, the Inspector-General of Forests, about changing the date of the official tree-planting season by the Forest Department.

"All of a sudden trees were before me : the trees of Naimisharanya under the shade of which our culture was born ; the trees which gave to those, who planted them, the religious merit of having ten sons for each tree ; the trees of which the Vedic Rishis sang 'May the gods, the waters, plants and the forest trees accept our prayers' ; the trees which Shakuntala daily watered before she took her food ; the trees, the new shoots of which she would not pluck lest their feelings might be hurt ; the trees and groves of Vrindavana and Nandanavana.

"As also *Kalpa-Virksha* (the wishing tree) our symbol of plenty ; the *Devadaru* tree which Lord Shiva adopted as a son when injured and whom Parvati herself nursed ; the *bel* tree, sacred to Shiva ; the *Akshayavat* from which the sinner can jump to salvation ; the *Bodhi* tree which threw its peaceful shade over Lord Buddha when he attained Enlightenment ; the *Peepul*, daily worshipped by many as the embodiment of Brahma, Vishnu and Shiva ; the *Parijataka* and *Tulsi*, so cherished by Shri Krishna and worshipped in many homes. And His words from the *Gita* came to me : 'Among the trees, I am *Aswattha*'.

"And I wrote the appeal to the country to observe the *Vana Mahotsava*.

"Possibly, there were other reasons too which attracted me to forests. I had lived for years in a noisy industrial city like Bombay, and my heart always yearned for its antipodes – the forest – where alone I found peace and calm. Nothing had left a deeper impression of loveliness on me than the play of shadow and sunlight as when in Matheran I walked between the high-branched trees. And in the leaf, the twig and the branch, as they swayed in the breeze, I had always found a mysterious world of beauty comparable in freshness only to a young maiden's first love.

"And the beautiful words of Turgeniv always come to me, when I am in a forest.

"And here is the forest. Shade and silence. The stately aspens are whispering high over-head ; the long, overhanging branches of the birch are barely stirring ; a mighty oak stands, like a warrior, by the side of a beautiful basswood. ...... You drive along the green road speckled with shadows. ...... The golden voice of the warbler rings with innocent loquacious joy ; it blends with the odor of the lilies of the valley. ...... But now a breeze has arisen, and the crests of the trees have begun to ripple, like waves. ...... Here and there tall blades of grass are protruding through last year's brown litter ; mushrooms stand apart beneath their caps. ...... The whole of life unfolds lightly and swiftly, like a scroll.

"Just as the first few days of my term of office were connected with *Vana Mahotsava*, so were the last few days of my expiring term.

"On May 12, 1952, happened the most important event in my ministerial career. After 59 years, the Old Forest Policy of India was replaced by a new National Forest Policy.

"Since May 1950, when the lure of trees had come upon me, many things had happened. I had felt deeply interested in the place which forests occupied in our country's economy. Vana Premi Sangh was founded. *Vana Mahotsava* had been accepted by the country as a national festival ; several crores of trees had been planted in three years, about one-half of which have survived. The festival had come to be copied in foreign countries. Italy celebrated its Festival of Arbor in Rome ; the privilege was then given to me to preside on the occasion. F.A.O. also, at its session in 1951, recommended all member-Governments to celebrate *Vana Mahotsava*. Several foreign countries have copied our festival.

"In the course of my term, I had also learnt many things. All advanced nations lacked the wood needed for reconstruction, for industry and for agricultural expansion. In Western Europe, for instance, the lack of wood retarded both speedy reconstruction and industrial recovery.

"There was also a general movement in many countries to try to control the major destructive forces ; the indiscriminate felling of trees ; apathy towards tree-planting, shifting cultivation ; over-grazing ; excessive utilization of productive forests ; a clear realization of the value of forests in man's struggle for survival.

"Our forest problem was more acute and needed immediate attention. India had only 20 per cent of forest area as against $33\frac{1}{3}$ per cent which she should have ; that is, we want about two thousand crores more trees to be self-sufficient. Our land-use was neither balanced nor complementary ; and our forests, such as they were, were being thoughtlessly exploited. Trees were being cut down by the villagers wherever they could. It was difficult to awaken in the masses the sense how deadly serious the danger was.

"When we lack food, the need is acutely felt in the immediate present. When we want forest products, the need is not felt so urgently, for the effect is spread over a long period. It does not cause unrest in the present. The newspapers which keep us grievance-conscious all the time are not interested in such long-term affairs. There may be excessive downpour in the Godavari districts ; Bihar rivers may be in floods ; dust-storms may overtake Delhi. To the public they are just natural calamities. Few have the knowledge to read these writings on the wall that somewhere, somehow the reckless destruction of forests is undermining the health of the collective organism of our life, and survival is becoming more and more difficult.

"Then the work of arresting the march of the Desert began ; the Board of Forestry, then newly set up, embarked upon a co-ordinated effort between the Centre and the States to reconsider the whole forest policy. The national Forests Policy was the result. As I stated in the foreword notifying the Government Resolution of May 12, it was a landmark in the progress of the nation.

"On the morning of May 14, when I left Delhi, perhaps at the very time, Dr. Deshmukh took over the work which had been begun in his able hands.

"The movement, during the last two years, has gone forward steadily. The Wild Life Committee has begun functioning. The Board of Forestry has been translating the National Forest Policy into action. More concerted efforts are being made to plant the maximum number of trees in the country and to preserve them as far as possible.

"The figures of trees planted in IV *Vana Mahotsava* (1953) have not yet been available, but I have little doubt that the total number of trees planted during the last four *Vana Mahotsavas* could not be less than ten crores.

"In U.P. alone, during the four *Vana Mahotsavas*, about two crores and fifty lacs of trees were planted out of which 70% have survived. Whereas in 1949 the Forest Department only planted 4,034 acres, in the II *Vana Mahotsava* it planted 6,317 acres, in the III, 8,871 acres ; and in the IV, 11,570 acres. In the V *Vana Mahotsava* it is proposed to plant about 13,000 acres.

"You will see what progress is being made and how baseless the criticism is.

"On June 29, 1951, when announcing a Ten-Year Land-transformation programme, I first referred to the growing menace of the desert.

"The first nursery in the plan to arrest the Rajasthan Desert was inaugurated late in 1951. Soon the control of erosion became a live issue in the country, and strenuous efforts are now being made by the Central and the State Governments to fight this menace.

"In Uttar Pradesh alone the Rajasthan Desert is encroaching at the alarming rate of about 32,000 acres per year. On an estimate, three million acres of good productive land have already been converted into ravines. Another six million acres under cultivation have been so damaged that their productivity is only 25 to 50 per cent of that of the normal land.

This devastating process has been affecting the great Vrajabhumi of old – the Mathura, Agra and Etawah districts – which once formed the most fertile tracts in India.

"To fight this menace a scheme has been put into action to plant trees over the Agra–Mathura Road and the Govardhan–Barsana Road; to restore to its ancient glory the *Parikrama* path at Giriraj Govardhan; to establish tree lands in the interior of the districts; to take measures for erosion-control in the Giri-Govardhan area; and to reclaim the ravines in these districts. The work so far done consists of plantation of over 5,295 acres of land and 20 miles of roadside avenues. In the V *Vana Mahotsava* of 1954, the plantation target is 6,700 acres of land and 28 miles of roadside avenues.

"Recently I saw the work that is being done on the shores of the Arabian Sea in Saurashtra to arrest the desiccating vigour of the hot winds. In less than two years plantations are springing up where there was nothing but a dreary stretch of sand-dunes.

"The Government of India have now set up a Soil Conservation Board at the Centre. I trust this organization will co-ordinate and impart a drive to conservation measures throughout the country.

I am not exaggerating when I say that the future of India is bound up with the success of *Vana Mahotsava*. Not only the future of India, but the future of man, as has been recognized by all advanced countries, is bound up with trees.

"Few realize the crisis which is coming over man through a serious disturbance of the equation between population and resources.

"To-day the population of the world is 2,500 millions. By 2,000 A.D. 1,000 millions more would be added; and of the total of 3,500 millions on this globe, 1,000 millions would be starving even if the food resources increase at the present rate. Under modern conditions you dare not permit large-scale devastating famines. Even wars are no solution. In spite of the loss of life involved in the World War II, to-day Europe has fifty million more people than in 1930.

"In India, in 1951, the human beings number 360 millions; cattle 176 millions; goats and sheep 80 millions. In 1961 the human population will be 410 millions, cattle population 220 millions, goats and sheep population, 95 millions.

"To feed our population we have, on the present level of consumption, 75 million tons of agricultural produce; by 1961 we will require 10 to 15 million tons more.

"But even if all our planned irrigation projects are completed in time, in 1961, we would have only $\frac{2}{5}$ of our needs. If food production is increased as planned, we would be short by 3 million tons in that year.

"The estimated increase, however, depends upon high power efficiency in every aspect of Land Transformation which has yet to be achieved. This implies a systematic control of growing erosion, which means trees; the arrest of the march of the Desert, that is trees; supplementary diet in foods, that is trees; more and more leaves to serve as manure, which means trees; more and more conservation of water, which, again, means trees.

"To-day, the estimated requirement for our population is 500 million acre feet of conserved water; our available facilities only provide 76 million acre feet; we are, therefore, short by 424 million acre feet. When all our irrigation works which have been planned are completed, the total amount of water conserved will be 176 million acre feet; our requirements would have risen to 560 million acres; our deficiency would be 380 million acre feet.

"In order to regulate our rains, we want trees; to prevent the rains running away with the top-soils in our water-channels, we want trees; to prevent floods, we want trees. Trees are the cheapest means of preserving water; each tree is a dam. The challenge of billions of rain-drops can only be met by millions of tremulous leaves.

"To-day, even as it is, there is not enough fuel to meet the needs of the present population and trees are being mercilessly cut down. With the growth of our population we will require still more fuel ; all that means fuel forests for every village.

"Food sufficiency cannot be attained by cutting down forests. I find in the hills, that land, pre-eminently fitted for fruit-trees and forest, is converted into agricultural land. You destroy the forest ; you exhaust the thin top-soil of the hills in a few years' time ; you will be left with neither the forest nor agricultural land. And erosion of the hill-sides will dry up the rivers and convert the plains into deserts.

"Rapid expansion of intensive agriculture with the aid of tractors and scientific fertilizers has its dangers too. In less than a century, under intensive cultivation by scientific means carried on in disregard of the needs of the soil, large areas in America have become deserts.

"Recently I read of the fate which overtook the Mayan civilization in Yucatan. The Mayans were a powerful and ingenious race. As described by a historian 'they were the most brilliant aboriginal people on the Planet'. They built huge palaces and temples ; they knew mathematics and astronomy. Their material achievements are attested by the magnificent ruins they have left.

"They have disappeared from the face of the Earth. Their mighty edifices are a colossal wreck. In the words of Shelly—

Round these ruins, boundless and bare

The lone and level sands stretch far away.

Why ? Asks the ecologist. The Mayans discovered the maize, the finest and the richest foodgrain in the world. They intensively cultivated it for centuries. They flourished ; they multiplied with vigour ; they lived with happy hearts.

"But the soil, so rich once, has no top-soil left now ; it is a stretch of bare lime-stone rock.

We must never forget the lesson of the Mayans. Their land had no domestic cattle ; they had therefore no need for hay and therefore no use for crop rotation. There was no manure either and no forests ; nothing to replenish the soil.

In a thousand years the Mayans ate up the corn ; the corn-fields ate up the forests ; the corn ate up the top-soil ; and all that was left was death and an endless, empty scrub-jungle.

"Let us take the lesson to heart ; let us realize that the climate and the land and those who live in it form a single inseparable collective organism.

"You dare not part the soil, one of the elements of which the Collective Organism of life is built, from the other elements, the man, the cattle, the tree and the plant. Man cannot flourish at the cost of the soil, the tree or the plant. No single element can be exploited without disrupting the Cycle which supports the life of the organism.

"What I stated three years ago, I tell you again : India wants 2,000 crore trees. Everyday that we fail to realize it, we complicate an almost insoluble situation.

"Even if we plant 5 crore trees every year, of which 3 crores survive, by 1961 we would have only 30 crores. And we have a long way to go. That is why I said it once, said it twice and will say it again, what I stated in 'If I were a Khalif' :

> "I would have a tree planted every time a child is born a marriage is solemnized or a death occurs".

"I would, therefore, invite you to go to your work with the faith that you have a mission, a great mission, to spread the message of *Vana Mahotsava*, so that India might live",

The proceedings of the Convocation had been opened with the following speech by the President of the Forest Research Institute and Colleges, Shri C. R. Ranganathan.

"Shri Rajyapal, Ladies and Gentlemen,

"I rise to open the proceedings by extending a cordial welcome to everyone present here at this Convocation. In particular I welcome Shri K. M. Munshi who is honouring us for the third time by taking a prominent part in our annual convocations. On his side this is a measure of the interest he takes in Indian forestry and in the affairs of this institution. On our side it is a mark of the respect and regard in which he is held by the forestry profession and of the value that it attaches to his counsel and support. We welcome him as our ex-Minister, and as the Head of the State we live in. But he is specially welcome as a friend, protagonist and patron of Indian forestry. It is unfortunate that this Institute is not empowered to confer honorary diplomas or degrees. If it had been so empowered, I feel sure that the highest honorary diploma would have been conferred on him and following a recent precedent, this convocation might have witnessed the interesting spectacle of Shri Munshi admitting himself formally and honorarily to the ranks of professional foresters.

"We are going to break new ground at this convocation to-day by awarding All-India *Vana Mahotsava* Shields for 1951 to their winners. The actual winners are not individuals, but Meerut district in Uttar Pradesh for the Rajendra Shield, Periyaram village in Malabar District of Madras for the Jawahar Shield, the Military Farm at Srinagar, Kashmir, for the Sardar Patel Shield and the Andhra University for the Munshi Shield. Distinguished representatives of the States and organizations concerned are present here to-day to receive the awards. I extend a hearty welcome to them. It is a happy circumstance that they will receive these shields at the hands of Shri Munshi, the originator of *Vana Mahotsava*.

"As usual there have been some changes of staff in the colleges. These will be mentioned in the report of the Director of Forest Education. But I may perhaps refer to two major changes – one an accession and the other a loss. Shri K. B. Mohan Lal of the Indian Forest Service in Assam took up the post of Director of Forest Education on 4th May 1953. In December last Shri V. P. Mathur relinquished charge of the post of Dean, Indian Forest College, a position which he had held for nearly seven years with distinction. During this long period, he was responsible for the training of several hundred forest officers for our States. I should like to take this opportunity to pay a well merited tribute to Shri Mathur for this steadfast devotion to duty, his truly remarkable capacity for sustained work, his quiet competence and his wholesome influence on the successive batches of students that have passed through his hands. His going is a serious loss to us, but we are glad to think that our loss is the gain of Madhya Pradesh, where, I understand, his services are being retained as a Conservator, after his superannuation.

"I should like finally to refer to one major development in the training of our forest officers. At its meeting at Dehra Dun in June 1953, the Central Board of Forestry approved of a proposal to extend the existing two-year course of Superior Forest Officers by one year, the first six months of which should be spent in practical training in the States and the next six months in the Forest College at Dehra Dun. The proposed third-year course should count for service and increment of pay and in view of the expansion of the course no preliminary training in the States before admission to the College was considered necessary. This recommendation arose out of the realization that the present two year course was already far too crowded and allowed of little scope for the intensification and expansion of the course to cover the great developments that have taken place in the field of technical forestry in recent years. We expect to implement the recommendation of the Board of Forestry with the course starting from tomorrow.

"I will now ask the Director of Forest Education to read his report".

The Director of Forest Education, Shri K. Mohan Lal, I.F.S. then read his report. Before

doing so he read an inspiring message from Dr. Punjab Rao Deshmukh, Minister of Agriculture, Government of India, which ran as follows :—

"It is almost a truism that forest development is a vital part in national development. I am sure, those who have had training at the Forest Colleges and the Forest Research Institute, Dehra Dun, would convey, by precept and practice, the utmost value of afforestation. I would indeed appeal to them to remember in all their endeavours the national forest policy of India as enunciated by the Union Government.

I wish them all success".

The report of the Director of Forest Education and his announcement of the results ran as follows :—

Shri Munshi, Ladies and Gentlemen,

"Now I beg leave to present the report on the working of the 1952–54 courses of instruction in Forestry, the students of which are passing out to-day, as also in the general working of the Forest Colleges at Dehra Dun during the year 1953–54.

"As in the past, two parallel courses were conducted a Superior Forest Service Course at the Indian Forest College for Forest Officers, and a Forest Ranger's Course at the Indian Forest Ranger College for Forest Rangers.

"The Indian Forest College which trains officers for the Superior Forest Service dates from 1938. But it may be recalled that officers of the Indian Forest Service and the Provincial Forest Service were being trained so far back as 1912. The Indian Forest College conducts a two-year course for the training of the gazetted forest officers of the various States of the entire Union as well as for our close neighbours. Thirty-nine (39) officers are passing out to-day.

"The Indian Forest Ranger College is an even older institution and dates back to 1878. It was indeed, the fore-runner and origin of this Institute of ours which has now grown to its present proportions and has established itself as a world famous and unique institute of its kind. Over a period of 75 years the Ranger's College has trained about 2500 Forest Rangers who form the backbone of the Forest Services all over India. Many of these Rangers have risen to high positions. To-day, 71 Rangers are passing out from this College.

"Admission to the two Colleges is confined entirely to nominees of the State Governments and neighbouring countries. Although these courses serve primarily the requirements of States in India, candidates from adjacent countries such as Nepal, Iran and Ceylon have also been trained here from time to time. Amongst these who are to-day passing out successfully after completing their course, there are three foreign students two from Ceylon in the Indian Forest College and one from Nepal in the Indian Forest Ranger College. This Institution has been recognized by the Food and Agriculture Organization of the U.N.O. as an International Training Centre for Asia and the Pacific. Under the Government of India Cultural Scholarship's Scheme for studies in India, five seats in the Diploma Course and ten seats in the Ranger's Course in Forestry for candidates from abroad, both of Indian and non-Indian origin, are kept reserved each year.

"*Courses of studies*—The courses followed well established lines. These include studies in the lecture rooms in the laboratories and in the Field. In addition to all aspects of commercial and state forestry, the students of both the Colleges have also had the benefit of instruction in soil conservation, planned land use road-side avenues, canal bank plantations, farm-forestry and several other specialized practices for which forest officers are now called upon to assist and advise in an increasing degree and through which the trained forest officer will be able to contribute more and more to the welfare and uplift of our predominantly agricultural population. Instructions and practical training is also given in extra curricular activities such as Rifle practice.

"A wild life club has been recently inaugurated in the Indian Forest College primarily with the object of inculcating a love for wild life amongst the young forest officers and to train them in correct method of nature study with particular reference to game preservation. These activities were further augmented by the introduction of facilities for out door hobbies, such as photography. As in the past the Commandant, National Defence Academy so kindly provided facilities for giving a month's training in riding to the officer students this year also.

"Eminent forest officers of the F.A.O. and the States and Geological Survey of India were invited to deliver lectures to the students on their own special subjects.

"To all these officers, who took up lectures at the two Colleges, as well as to those research officers who in addition to the lectures, supervised and guided individual students in their special advanced study, I take this opportunity of expressing our gratitude.

"*Tours and field work*—In keeping with the essentially practical nature of a forester's duties, the courses involved quite half the period in each year in practical field work under varied forest conditions, for which purpose tours to the various forests in the country were conducted as usual. Our sincere thanks are due to the various forest officers in the States through whose co-operation these tours could be completed successfully.

"*Examination and results*—Senior Forest Officers from States, Research Officers from the Institute and other external examiners were invited to examine the students in the first year's and the final examinations. We are grateful to these officers for undertaking this responsibility in the midst of their own multifarious duties. The students were also assessed as usual for work done on tours, for practical field work, and for general proficiency and conduct.

"*Staff*—The regular staff of the two colleges consists of forest officers on deputation from different States who conduct the classes in forestry subjects and are responsible for all the field training. In addition, the students get the benefit of training from highly technical officers of the Research Institute who are specialists in their own fields. Besides these research officers and serving forest officers, there are on the staff of the colleges separate lectures for Engineering, Surveying and a Physical Training Instructor.

"*Health*—The general health of the outgoing students of both the Colleges remained sound throughout the course, except for minor ailments, which are inevitable where such a large number of students is concerned.

"*Games and Sports*—Robust physique and sound health being one of the essential requirements for the efficient discharge of a forest officer's duties, physical training in the morning and games in the evening continued to remain compulsory while the students were at headquarters.

"I shall now, in my capacity as the Dean of the Indian Forest College, announce the results. I have great pleasure in announcing that all the 39 students of the 1952–54 Course of the Indian Forest College have successfully completed the Diploma Course of training in Forestry. I am further glad to announce that—

(1) Shri M. P. Ray of West Bengal
(2) Shri Hari Kant of Uttar Pradesh
(3) Shri R. B. Johri of Uttar Pradesh
(4) Shri E. V. S. S. S. Venugopal Rao of Andhra

have qualified for the award of Diplomas with Honours.

"By the award of the Diplomas, the recipients become Associates of the Indian Forest College and are entitled to the use of the letters 'A.I.F.C.', after their names as a distinction of their technical training at this College.

"I now have the pleasure to announce the results in order of merit and would request the students whose name is announced to approach the dais to receive the Diploma. May

I request you, Sir, to be kind enough to give away the Diplomas and Prizes to the successful candidates".

INDIAN FOREST COLLEGE, DEHRA DUN

FINAL RESULTS OF THE 1952–54 COURSE

Serial No.	Name of Student	State	Serial No.	Name of Student	State
In order of merit.—			16	A. S. SIDHU	P.E.P.S.U.
HONOURS DIPLOMAS (for securing 75% marks and over).—			17	S. N. KHARE	Madhya Pradesh
			18	O. P. MATHUR	Rajasthan
1	M. P. RAY	West Bengal	19	B. K. JHALA	Saurashtra
2	HARI KANT	Uttar Pradesh	20	T. S. PATYAL	Himachal Pradesh
3	R. B. JOHRI	Uttar Pradesh	21	T. K. MISHRA	Bihar
4	E. V. S. S. S. VENUGOPAL RAO	Andhra	22	R. N. KAUL	Vindhya Pradesh
PASS DIPLOMAS (for securing 50% to 74% marks).—			23	V. R. NEELAY	Madhya Pradesh
			24	A. G. OKA	Madhya Pradesh
			25	Y. K. SAHU	Madhya Pradesh
			26	G. S. DAVE	Madhya Pradesh
5	G. C. PANDE	Uttar Pradesh	27	S. V. PATHY	Madras
6	S. C. THIPPESWAMY	Mysore	28	A. K. KRAIPAK	Kashmir
7	A. D. R. RATNARAJAH	Ceylon	29	P. S. RAO	Hyderabad
			30	R. A. P. CHOUBEY	Bihar
8	P. A. MUKHEDKAR	Hyderabad	31	P. B. V. REDDY	Andhra
9	H. P. SHARMA	Himachal Pradesh	32	S. PRASHAD	Uttar Pradesh
10	M. P. GUPTA	Punjab	33	JAGAT NARAIN	Uttar Pradesh
11	J. C. NAUTIYAL	Uttar Pradesh	34	M. N. MITRA	Orissa
12	K. V. S. BABU	Andhra	35	A. D. MESHRAM	Madhya Pradesh
13	M. N. VAISHNAV	Saurashtra	36	D. B. MISHRA	Orissa
14	S. C. PADHI	Orissa	37	S. K. NIGAM	Vindhya Pradesh
15	E. W. SENEVIRATNE	Ceylon	38	L. K. HAZARIKA	Assam
			39	R. K. MATTOO	Kashmir

Now I shall call the Prize Winners, and may I request you, Sir, to kindly give away the Prizes ?

LIST OF PRIZE WINNERS

Serial No.	Prize	Name of Student	State
1	HONOURABLE MINISTER'S PRIZE FOR STANDING FIRST	M. P. RAY	West Bengal
2	COLLEGE PRIZE FOR SILVICULTURE	M. P. RAY	West Bengal
3	COLLEGE PRIZE FOR FOREST MANAGEMENT.	M. P. RAY	West Bengal
4	COLLEGE PRIZE FOR ENGINEERING AND SURVEYING.	M. P. RAY	West Bengal
5	COLLEGE PRIZE FOR BOTANY	P. A. MUKHEDKAR	Hyderabad
6	BEST ALL-ROUND STUDENT AND THE MOST PRACTICAL FORESTER.	A. D. R. RATNARAJAH	Ceylon
7	F.R.I.'S PRIZE FOR THE BEST STUDENT WHO HAS SECURED HONOURS DIPLOMA AND WHO HAS NOT RECEIVED ANY OTHER PRIZE.	HARI KANT	Uttar Pradesh

"Shri M. P. Ray (from West Bengal), who stands First, is being recommended for the award of the Currie Scholarship. The scholarship is paid from a trust fund in England to the student of the Indian Forest College who obtains the highest marks for the Course.

"Mr. Currie was Vice-President of the Council of India and in 1887 established the fund for prizes to be awarded to the probationers trained at the Royal Indian Engineering College at Cooper's Hill for the Indian Forest Service."

After the diplomas and prizes had been awarded to the outgoing students of the Indian Forest College, Shri G. S. Dhillon, Principal, Indian Forest Ranger College announced the results of the 1952–54 Course of the Ranger College and requested Shri Rajyapal to award the certificates and prizes to the successful candidates. He then called the students in their order of merit for the award of certificates to them.

INDIAN FOREST RANGER COLLEGE, DEHRA DUN

EXAMINATION RESULTS—FINAL OF 1952–54 COURSE

Serial No.	Name of Student	State
In order of merit.—		
HONOURS.—		
1	J. Talukdar	Assam
2	Baldev Singh	Himachal Pradesh
HIGHER STANDARD.—		
3	V. S. Saxena	Ajmer
4	H. M. D. Srivastava	Uttar Pradesh
5	P. K. Kar	Tripura
6	Mansoor Ahmad	Bihar
7	Ved Prakash	Bhopal
8	C. P. Singh	Bhopal
9	Thaker Dass Sharma	Kashmir
10	U. N. Prasad	Bihar
11	K. S. Mehta	Uttar Pradesh
12	V. D. Tare	Madhya Bharat
13	G. A. Naqaash	Kashmir
14	B. Masanta	Bengal
15	G. M. Shah	Kashmir
16	K. C. Chetia	Assam
17	P. R. Roy	Uttar Pradesh
18	Kirtiman Tamang	Nepal
19	Girish Chandra	Uttar Pradesh
20	R. K. Kapuria	Madhya Pradesh
21	Suraj Pal Singh	Rajasthan
22	B. L. Poonia	Rajasthan
23	R. Agrawal	Madhya Pradesh
24	K. K. Patil	Madhya Pradesh
25	B. N. Singh	Uttar Pradesh
26	B. Panda	Bihar
27	T. C. Nag	Himachal Pradesh
28	Puran Chand	Uttar Pradesh
29	B. K. Beri	Madhya Bharat
30	H. C. Joshi	Uttar Pradesh
31	S. V. Khemaria	Madhya Bharat
32	J. B. Roy	Bihar
33	L. Indrajit Singh	Manipur
34	P. P. Gupta	Rajasthan
35	Jagannath Goel	Himachal Pradesh
36	P. S. Guleria	Himachal Pradesh
37	M. K. Verma	Uttar Pradesh
38	B. K. Haldar	Bengal
39	G. A. Jan	Kashmir
40	S. N. Prasad	Bihar
41	S. K. Vyas	Bhopal
42	H. S. Singh	Uttar Pradesh
43	D. K. Mitra	Bhopal
44	J. P. Agrawal	Madhya Pradesh
45	S. D. Joshi	Madhya Pradesh
46	V. N. Singh Tomar	Madhya Bharat
47	Indrajit Khati	Sikkim
48	P. C. Bahinipaty	Orissa
	B. P. N. Sinha	Bihar
50	Purakh Singh	Kashmir
51	R. P. Bhardwaj	Himachal Pradesh
52	S. L. Sharma	Rajasthan
53	K. C. Joshi	Uttar Pradesh
54	S. P. Singh	Uttar Pradesh
55	P. N. Bhatia	Saurashtra
56	M. R. Sarma Roy	N.E.F.A.

(*contd.*)

INDIAN FOREST RANGER COLLEGE, DEHRA DUN—(*concld.*)

EXAMINATION RESULTS—FINAL OF 1952–54 COURSE

Serial No.	Name of Student	State	Serial No.	Name of Student	State
57	U. G. Sant	Madhya Pradesh	66	H. L. Saha	Bengal
58	Virendra Singh	Madhya Bharat	67	P. C. Roy Choudhury	N.E.F.A.
59	D. S. Negi	Uttar Pradesh	68	P. K. Roy Choudhury	Bengal
59	M. H. Ansari	Uttar Pradesh	69	R. N. Charan	Bihar
61	A. C. Banshpal	Madhya Pradesh	70	U. K. Barman	Assam
62	S. S. Sanyal	Bihar	71	P. N. Datta Gupta	Bengal
63	R. Choudhury	Assam			
64	H. B. Nistane	Madhya Pradesh			
65	G. Gogoi	Assam			

INDIAN FOREST RANGER COLLEGE, DEHRA DUN

PRIZES AWARDED TO THE 1952–54 COURSE

Serial No.	Name of Prize	Name of Prize Winner	State
1	HONOURS GOLD MEDAL—(To the student who gets the highest total number of marks and honours).	J. Talukdar	Assam
2	FERNANDEZ GOLD MEDAL FOR FOREST UTILIZATION.	J. Talukdar	Assam
3	SILVER MEDAL FOR FORESTRY	J. Talukdar	Assam
4	SILVER MEDAL FOR FOREST ENGINEERING.	J. Talukdar	Assam
5	SILVER MEDAL FOR BOTANY	V. S. Saxena	Ajmer
6	McDONNEL SILVER MEDAL—(To the best student from the Punjab or Kashmir).	Thaker Dass Sharma	Kashmir
7	WILLIAM PROTHERO THOMAS PRIZE—(To the best Practical Forester).	Thaker Dass Sharma	Kashmir
8	"INDIAN FORESTER" PRIZE—(To the best student who has received no other prize). (This will be in the shape of free subscription to Indian Forester for a period of the year).	H. M. D. Srivastava	Uttar Pradesh
9	PRINCIPAL'S PRIZE—(To the student who gets the highest number of marks in Range administration (Forest Law, Accounts and Procedure).	Baldev Singh	Himachal Pradesh
10	INSPECTOR-GENERAL OF FORESTS' CUP—(To the winner of the Marathon Race).	P. S. Guleria	Himachal Pradesh
11	HAZARIKA MEMORIAL PRIZE—(To the student who does best in tour examinations).	Baldev Singh	Himachal Pradesh

Shri Rajyapal then presented the Howard Medals for 1952 and 1953 to two officers (Research Assistants) of the Forest Research Institute, namely, Shri G. V. Karira (B.Sc. Agri.) and Kasturi Ramachandra Rao, M.E., for their distinguished research work on the subjects "Distillation of camphor yielding Ocimum" and "F.R.I.—Diaper" respectively.

The Inspector-General of Forests, Shri M. D. Chaturvedi, then requested Shri Rajyapal to present the four All-India *Vana Mahotsava* Shields to their recipients. In doing so he said : "Shri Munshi, Shri Ranganathan, Fellow-workers, Ladies and Gentlemen,

Shri Munshi is no stranger to you. Strangely enough he continues to be a stranger only to me.

"When I met him last month at Delhi, he handed over to me a brochure describing the activities of the Academy of Letters which this man of letters founded 15 years ago. Now, there is nothing strange in his founding an institution ; many others can claim similar distinction. But what is strange, what is a matter of an eternal surprise to me is the flame in him which burns brighter and brighter with advancing years and lights up everything that this Great Delicate Man does. Be it his dissertation on Art and Culture or observations on food and agriculture ; be it the reconstruction of the Temple of Somnath or the historical romance he once wrote : Jai Somnath ; be it the founding of the Academy of Letters or the Kulpati's letters in the *Sunday Press*, his creations bear the glow of his artistic genius.

"Believe me, I never could read the brochure he gave me ; I could not even hear what he said. What engrossed me was his personality. For, Shri Munshi is vastly greater than all his acts, deeds and words. What surprises me is not what he does, but what he is. The point which Euclid wanted to make and could not was not that his point had no magnitude but that its magnitude was immeasurable. The point I wish to make about Shri Munshi is that he is inponderable. To measure Munshi is not a Herculean but a Euclidean task.

"Among the many movements which owe their inception to Munshi, the *Vana Mahotsava* – the Great Festival of the Trees will bear testimony to his creative genius for all time to come. Shri Munshi imparted a sacred import to the trees, which I once described as silent sentinels which guard the Mother Earth. He revived memories of the glorious green of our forests which once covered the land and cradled the Aryan civilization. He dived deep into scriptures and derived inspiration from the sayings of saints and sages who had drawn inspiration from their sylvan surroundings. He instilled in all and sundry a love for trees. True, our great festival of the trees owes its inception to Shri Munshi. But what Shri Munshi owes to this festival merits better recognition. The movement he engendered attracted world-wide recognition. It led to the adoption of the resolution on the World Festival of the Trees at the Food and Agriculture Organization of the United Nations at Rome. I handled his fan-mail. A letter from Germany said alas, 'we have no Munshi'. Nearer home the movement is fast being designated as Munshi-Utsava.

"A word to our scoffers, detractors and doubting Thomses. When a peasant plants a *nim* tree in front of his humble hut or a student nurses a *gold mohar* in his college campus, or when an *imli* is put out in a graveyard or a *pipal* planted beside a well, the objective, it must be clearly understood, is to provide shade and shelter against heat and swelter, and its motif is aesthetic not economic. To confuse this symbolic planting as replacing schemes of afforestation is to betray gross ignorance of the aims and objects of the movement. I have to contend against a lot of ill-informed criticism against *Vana Mahotsava* in the press, in the House of the People, in drawing-rooms and from public platforms, I welcome it for the opportunity it provides to enlighten the public opinion. But, when people, who ought to know better, cable garbled accounts abroad for the consumption of the British Public, suggesting that the good work of the Forest Department has been taken over by Generals, Governors and Babies in arms who plant trees where they should'nt, it becomes difficult to exercise

restraint in one's reactions. For, the lapse springs not from mediocrity which we all share, but from mendacity which we all abhor.

"I would now request you to give away the following All-India shields :—

(1) *Rajendra Shield*—Awarded to the district in the Indian Union which has done best both as regards the original planting and in the survivals as a result of such planting. The award goes to Meerut District in U.P. Shri A. N. Jha, Secretary to Government of U.P., Agriculture Department, Lucknow has been nominated by the State Government to receive the shield.

(2) *Jawahar Shield*—This is awarded to the village which has done best both as regards the original planting and survivals. The award has been made to Periyaram village in the Malabar District of Madras State. Shri R. Rajagopalan, Director of Veterinary Services has been nominated by the Madras Government to receive the shield.

(3) *Sardar Patel Shield*—This shield has been awarded in the similar manner, to the institution which has done the best. By institution is meant the District Board, Municipal Board, Forest or other College not affiliated to University. The award has been made to the Military Farm at Srinagar, in Jammu and Kashmir State. Lt.-Col. G. S. Dutta, Director of Farms and Rakhs has been nominated by the State Government to receive the shield.

(4) *Munshi Shield*—This is awarded to the University which has done best. The Andhra University has been awarded the shield. Shri K. B. Gopalaswami, Registrar of the Andhra University has been nominated by the University to receive the shield".

Shri Rajyapal then delivered his Convocation Address.

Finally the Inspector-General of Forests addressed the students giving them a few words of advice and also proposed a vote of thanks in the following words :—

"Shri Munshi, Ladies and Gentlemen,

"I have now to perform the excruciating task of inflicting upon the outgoing students a word or two of advice. While doing so it occurs to me that it is easier to look wise than to utter words of wisdom. I am reminded of a wise old lady who asked the Bishop, after he had finished reading a particularly long and tiresome sermon, 'Sir, how do you expect us to remember all what you say, when you do not remember it yourself and have to read it'. I have made it an inflexible rule never to repeat high sounding shibboleths which I cannot remember myself. For that reason I prefer to confine my remarks to my own experiences – experiences for which I paid dearly and the only thing I forgot about them was to take a receipt for the payments made.

"Among the many interesting experiences I have had, by far the most comic ones are those which relate to my harangues from this platform. I have indulged in the delightful task of regaling batches of young forest officers with stories of my own failures. Believe me there is only one thing more comic than giving advice, and that is taking it.

"I have, however, a great glorious secret to impart to you this morning. I am willing to give it away without any charge, provided you give me your solemn assurance that you will not pay the slightest attention to what I say. The secret is that should you want to fall in love with your forests, for God's sake do not let forestry detract you. Nothing kills a beauteous tree, its beautiful foliage or even more beautiful flowers so effectively as a Latin name. Enough unto me the mauve of *sandan*, the flame of *dhak*, the scarlet red of the cork

tree and the variegated colours of *kachnar* and its cousins. I am second to none in my admiration for the naturalist. But where I draw the line is that when the naturalist stands between me and Nature ; I draw the line when my admiration for him, begins to turn into beads of perspiration. I have no use for lenses which magnify without an eye at the back of them.

"Do you know gentlemen, how did Dr. Brandis the Father of Forestry in India, come to be a forester. Dr. Brandis was a Botanist at the University of Bonn. When he came to Burma, his vast library of books on Botany was lost in a boat which capsized going up the Irawady. Left without any books Dr. Brandis saw the wood for the first time which, otherwise, he could not for the trees. And, he became the greatest forester for all time. I sincerely pray that by some divine dispensation or trick of fate the books we have packed in your heads may be lost – lost irretrievably – to turn you into a forester, to make you a Brandis.

"I know I am talking heresy in this Temple of Forestry in the hearing of its High Priests. But then I am not a teacher of Forestry but a preacher of Forests.

"This morning I feel like being in a swing-door – the door which is swinging you in and swinging me out of forests. What a grand life awaits you. I would not like to spoil its picture by telling you the story. You have a great future ahead of you. I wish you all God-speed and great success in your career. May God help you to avoid all the pitfalls in which I fell and about which I dare not tell. And, if you must fall, fall in the pits into which I fell to enable me to tell you, 'I told you so'.

"I have another sacred but rather a sad duty to perform, and that is to bid you all farewell. For, my time is up, and I have come to the end of my course of the relay race. I will soon be handing over the Torch I have carried for 5 long years. I have, however, the satisfaction of handing over this Torch to hands vastly worthier than mine. May this Torch burn brighter and brighter and emanate both light and warmth. I have only one stipulation to make and that is :

'*Shama main aag rahe sar pai qasam khanai ko dekhna, ye na jalai kisi parwanai ko*'.

(Let the torch bear on its head the flame to swear that it will burn no moth).

"Before I resume my seat, I must express my feelings of gratitude to Shri Munshi for having honoured us by his presence on this occasion. To the President of the Forest Research Institute, the Director of Forest Education and the Staff, I am particularly beholden for the excellent arrangements made for this function. I will be failing in my duty if I did not thank our guests who have responded to our invitation. And, to the Ladies in particular, I would like to owe an eternal debt of gratitude for brightening up this ceremony by their colourful presence. 'JAI HIND' ".

The proceedings came to a close with the calling of three cheers to the distinguished guests by the seniormost officer student who passed out this year.

AUSTRALIAN HONEY COMES FROM THE TREETOPS*

BY P. D. MANTLE

Open a tin of Australian honey, taste it, savour it slowly, and you may notice a subtle flavour that is different from most honeys you know. It is not so distinctive as the heather honey of Scotland or the saffron honey of Kashmir, but if you have a keen palate you will probably catch the elusive flavour characteristic of Australian honey. It comes from the eucalypts, the gum trees, whose blossom is the main source of nectar for the bees who provide the primary labour force of a minor Australian industry.

Many eucalypts (and there are some hundreds of varieties in Australia) have blossom rich in nectar. Those most favoured by apiarists are the Yellow Box, Mugga Ironbark, and the Stringy Bark.

Many full-time professional beekeepers find it worth their while to transport their hives and equipment around the countryside to where the trees are blooming best. One such wanderer crossed the continent twice, following the honey flow. That was exceptional, but in a single season many beekeepers cover a thousand miles and more, taking with them their hives and equipment and a caravan to live in. Such men, in a favourable season, might take as much as 500 lb. of honey from a single hive.

Professionals are the main source of Australian honey, and they need to keep up a high rate of production from each hive if they are going to make it their sole source of income. They make a study of the seasons and flowering times in different parts of the country. They keep in touch with the various Departments of Agriculture which advise them about the blossoming of eucalypts. And they know that many trees can be relied upon to blossom 12 months after they have made bud development.

Though the familiar gum tree is the main source of the honey flow, apiarists value the flowers of clover, lucerne (alfalfa) and of the thistles which grow as weeds.

There are mixed farmers who keep bees as a side line, and the amateurs who have a few hives that remain always in the same place. Their bees gather from home gardens and orchards. But the amount of honey that such people put on to the market is small and the weight of honey per hive is low. The full-time professionals, who make up about a fifth of the total number of beekeepers, provide the bulk of Australia's marketable honey and beeswax.

In the year ended June 30, 1953, there were estimated to be about 7,000 apiarists whose activities were on a scale that required them to send in statistical returns. Between them they had about 305,000 productive and 100,000 unproductive hives. The yield from each productive hive varies considerably from year to year according to the eucalypt blossoming. Many parts of Australia are subject to occasional droughts ; some parts have occasional or regular floods ; and in a great deal of the country there is a constant summertime danger of bushfire that can despoil thousands of trees and wipe out millions of bees. Since the first year of the war, average production has varied from 52 lb. to 138 lb. of honey from each productive hive. Production of beeswax in 1952–53 was about 360,000 lb.

Before the war, Australia did little more than produce enough honey for its own needs. But migratory bee farming began to take on and the trend continued after the war. This greatly increased the total production of honey, but home consumption, though increased by

* Received from the Press Attache, Australian High Commission, New Delhi.

the waves of immigrants, did not keep pace. In 1952–53 Australia exported 16,612,683 lb. of honey at an average price of about 11d. a lb. The United Kingdom was the main customer, taking 15,137,152 lb. costing £673,828. The Western Zone of Germany took 733,814 lb. and the remainder went to a variety of overseas markets.

Unlike the United States of America, Australia does not subsidize its honey exports. The overseas price is lower than the price for home consumption so equalization schemes operate to share between producers the high and the low-priced markets. South Australia is the only State with legislative power over honey acquisition and marketing, but voluntary organizations operate in other States to average out the producer's return.

Just how much honey Australians eat is not easy to compute, as there are varying carry-overs from one season to another. But the amount is undoubtedly small. Each year Australians eat something like 1·3 lb. of honey per head – and that includes the honey used in confectionary and liqueurs. On the home market it can be bought in 4-gallon tins, smaller tins, jars and waxed cartons. It is available as clear or candied, with or without a section of comb in it.

The main producing States are New South Wales, Victoria and South Australia, though honey is produced in all six States. As honey sources are as much as 3,000 miles apart, the flavour and colour varies according to the type of flora visited by the bees. But in preference to marketing special lines, packers usually prefer to make up standard blends achieved by a selection of the honeys used. This applies to the greater part of the output, though a few select lines are marketed. In general, Australian honey has a very high sugar content.

Apart from the substantial element of migratory beekeeping, apiary practice in Australia is very much the same as in other countries. The majority of hives are of the square bod variety with a removeable roof and vertical frames which are held by runner guides attached to the walls of the hive. They are usually mounted on legs and equipped with some device to prevent ants from entering. A landing platform is provided at the entrance to the hive which is usually a slit extending the width of one side. Dimensions vary, but a fairly average hive measures 18 inches square and 24 inches high.

The Italian type of bee is most common in Australia, and from time to time queens are imported from Italy. But the mating habits of bees make it difficult to maintain the purity of any desired strain.

There have been some recent developments in the artificial insemination of queen bees to maintain better control of purity of strain and to aim at the development of desirable qualities and swarming habits. Equipment for artificial insemination has been imported from the United States by the Department of Agriculture in New South Wales. This is supplemented by a considerable amount of material such as dissection microscopes, carbon di-oxide equipment and non-heating microscope lights to equip Glenfield Veterinary Research Station where work is now going ahead with the aim of improving the strain of bees. There is no export of queen bees from Australia.

The main honey-producing season is from October to March, which, in Australia is from the middle of Spring to the beginning of Autumn. The peak production year since 1938 was in 1948–49 when the total output of honey in Australia was 53,203,000 lb.

Probably the most interesting feature of the Australian honey industry is the group of itinerant apiarists. It was the sudden increase of these producers, with their rate of output, that made the industry more concerned with export than with home consumption. They are

the big producers. They have to be, for their costs are obviously higher than those of farmers who work from fixed locations.

When the blossom within bee-flight has been worked out the migrant apiarist loads his hives on to motor trucks, loads up his robbing, extracting and heating equipment, stocks the caravan with food for himself and possibly his family, and sets off to the next stand. Once there he sets out his hives and releases the bees. As a rule the bees have no great difficulty in finding their hive in its new location. So long as the queen remains in the hive they will return to her. From time to time a few swarms are lost, but they are more than made up by the stray swarms of bees that the apiarist can pick up occasionally.

While the bees work there is plenty to keep the apiarist occupied, for he must set up his equipment at the new site, including the honey house which he needs to make bee-proof to forestaff possible robber bees. And if the season is good he is kept hard at work robbing each hive as often as once in each 10 days. It's a good life, they declare, and most of them stay in the game year after year making their substantial contributions to the Australian honey industry.

BRIEF HISTORY OF MYSORE KHEDDAS

A RADIO TALK BY M. A. MUTHANNA
Chief Conservator of Forests, Bangalore

The Mysore Kheddas are so famous that they need no publicity. But at the same time, it may be said that there are few who know for example when and how it originated.

When the suggestion was first made to me by the All-Inida Radio, Mysore, to give a brief talk on the History of Mysore Kheddas, I felt that I owed a duty both to the fortunate few who will witness the operations and also to many others who may not share this opportunity and convey to them some particulars about these operations.

The word khedda is derived from a Hindi word meaning 'ditch' and now it is loosely used to denote an area surrounded by trench in which wild elephants are impounded.

The main object of holding kheddas is to capture large numbers of wild elephants with a view to minimizing the damage done by them to the ryot's fields.

Before the introduction of kheddas in Mysore, the usual method adopted to catch the elephants was the pit system. This system is still in vogue in South India namely in the States of Coorg, Travancore and Madras. This method was given up in this State as it was considered to be a very cruel form of sport. Besides these 2 methods of capture there are other methods which are occasionally used to capture one or two elephants which may visit the departmental elephant camp.

(*a*) By decoying : Here a female trained elephant is used to decoy a male. The roping and final capture of the male is both difficult and dangerous.

(*b*) By snaring : Nooses are set along the elephant tracks. Young one are generally thus caught.

(*c*) Drugging : Opium is mixed in a ball of tamarind and administered.

The first khedda was attempted by Hyder Ali in the middle of the 18th century. He, however, failed in his attempt and was so disappointed by his failure that he appears to have left a curse behind, stating 'that no one will succeed in their attempts'.

Again, in the middle of 19th century another attempt was made by Col. Pearson during the British Commission regime. This attempt also proved abortive.

It was not until the year 1873 that the first successful khedda operation was conducted by G. P. Sanderson. It may be truly and really stated that from this year the foundation of Mysore Kheddas was laid.

Though the Khedda method of capturing elephants had been in vogue in Bengal for many centuries before it was first introduced into Mysore State, there are many differences in the techniques. They are so different that it is safe to say that Mysore technique has evolved quite independently of the Bengal technique. In other words, Mysore did not borrow her technique from Bengal.

The main differences between the two systems are as follows :—

In the Bengal method, the elephants are first rounded up in the forests. After surrounding the herd, a wooden stockade or khedda is put up in the proximity of

the area. The elephants are then driven into this arena and captured. Thus, the stockade or kheddas are not permanently located but changed from place to place depending on the location of elephant herds. Whereas in the Mysore method, the kheddas are permanently established in definite spots. As a matter of fact, except for a few slight variations, the old khedda areas are still in use. These khedda sites are also located with a view to giving the spectators an excellent view of the driving operations. Thus, the Mysore method offers to the spectators an excellent opportunity to watch the drive in progress and also to share the thrills of watching the wild elephants moving near the gallery.

In Mysore, the khedda operations are being held periodically ever since 1873. Since then there have been 32 khedda operations and the total number of elephants caught (including the present catch) is 1,652. Not all the operations have been a success either. Many a time, the herds scenting trouble have driven back the driving party and made good their escape.

The elephants caught are generally sold to the public by auction, a few being retained for the use of the Forest Department.

There has always been a good demand for Mysore elephants on account of their superior breed as they are handier and more reliable.

The *Elephantidae* family contains eleven genera of which only two survive. The two are, v. (1) the elephant of Asia (*Elephas maximus*) and (2) the elephant of Africa (*Loxodonta africana*). The latter is more primitive in structure.

The Asiatic elephant is generally regarded of recent origin, i.e., about Pleistocene times and came to Asia from Ceylon originally. During this period when there was land connection with Ceylon they invaded India and wandered north up to the Himalayas and then spread along its base towards east and west. The elephant of Asia during historic times was distributed in Mesopatamia, Persia, Afghanistan, whole of India, Burma, Ceylon, China and Java. Due to increasing drought combined with man's actions it since became extinct in Mesopatamia, Persia, Afghanistan and China. Even in India, it has become extinct in many places like the Indus Valley and is now found in a few States like U.P., Bengal, Assam, Madras, Coorg, Bombay and Travancore. In India the relics are found in Mohenjo Daro which are believed to be about 5,000 years old and the elephant was used then probably for food and as a beast of burden 2,500 years later Lord Budha banned the eating of its meat.

The Indian elephant has been thoroughly studied in the past and the most authentic literature on the subject can be found in the original manuscripts of 'Hasthi Ayurveda' which was probably written about two thousand years ago.

The Indian elephant according to this ancient literature and Sanderson is broadly divided into four distinct breeds, distinguished by their physical conformations. The four breeds are *Munda, Bhudra, Mriga* and *Sankeerna* or mixture. *Munda*, termed *Kumeria* in Bengal, is considered a thorough bred.

All the details regarding the pregnancy and period of gestation of the elephant have been recorded in this ancient work. It is also recorded in this Sanskrit treatise that the wild elephants which are free are not usually subject to disease and only die from old age. Sanderson is also of the same opinion. The reason for this is stated to be their knowledge of certain medicinal plants with which they treat themselves by instinct, whereas elephants brought under captivity are said to be liable to 232 kinds of diseases.

The African elephant belongs to a different genus. The most notable difference lies in the fact that both the male and female sexes in Africa carry Ivory (Tusks).

I have now given you in brief, and I hope to your satisfaction, an account of the Mysore Kheddas.

I would be failing in my duty if I close this talk without a reference to the part played by us, foresters, in the conduct of this operation. For the forester, the word 'Khedda' is a nightmare. The preparation for a khedda starts six months before the crucial date and an enormous amount of planning and preliminary work has to be gone through with meticulous care. The climax is reached when the elephants are surrounded in the forests about fifteen days before the final drive. At this peak period, nearly two thousand shikaries are engaged to guard the elephants. This entire labour force has to be provided with rations which must be delivered to them regularly and promptly at the site. The rations include ragi, rice and condiments, as well as beedies, tobacco and betel leaves.

Forest Officers are detailed to supervise this labour and in times of emergency should be prepared to defend them from wild elephants. They have to be out continuously for several days and nights and eat and live with their men in the open. No shelter or bed is provided for them. Thus, the forester's part, though unseen, is of vital importance to the success of this operation.

4TH WORLD FORESTRY CONGRESS

FOREWORD

BY DR. PUNJABRAO DESHMUKH

Minister for Agriculture, Government of India, New Delhi

Separated from the rest of Asia by the massive Himalayan ranges extending over a length of about 1,500 miles, and isolated by the sea on its eastern and the western flanks, India may well be described as a continent within a continent. Straight as the crow flies, the distance between Simla (*c.* 7,200 feet), – the summer resort in the Himalayas of the erstwhile British Government, – and Cape Comorin is about 1,700 miles. The east–west extent of the country from Saidya (Assam) to Porbander (Saurashtra) is about the same ; the total area covered is about $1\frac{1}{4}$ million sq. miles.

Forests of this vast region naturally reflect reaction to a diverse range of climatic and edaphic factors, the extremes of which are provided by the snow-desert of the inner Himalayas on the Tibetan border, and the saline desert of Rajasthan. The mercury rises above 120°F. at Bikaner and dips down to – 47°F. at Dras (Kashmir). The annual rainfall presents no less striking a contrast, the range being furnished by Jaisalmer 5 inches and Khasi Hills (Assam) 40 feet !

The flora of India is as rich as it is varied, both in composition and value. The number of species met with in the region is estimated at 30,000 the vast majority of which are of no more than academic interest. The chief among the valuable timber species are the conifers (pines, firs and *deodar*) which occur in the Himalayas ; sal (*Shorea robusta*) – the principal species of the sub-tropical zone, and the well known teak (*Tectona grandis*) which is met with throughout the Deccan plateau. Other species of commercial importance are *Dipterocarpus* spp., *Acacia* spp., *sissoo* (*Dalbergia sissoo*), sandalwood (*Santalum album*) and bamboos. Plant associations exhibit variations typified by alpine vegetation, Himalayan conifers and oaks, sub-tropical and tropical deciduous forests, moist evergreens, estuarine mangroves and thorny xerophytes. In short, in the forests of this peninsula, we find a fair reflection of the vegetation of the entire globe. Few countries can vie with India in providing a venue for discussion on both the tropical and temperate forestry. And, it is just as well that the Tropical Forestry Congress has been merged with the forthcoming 4th World Forestry Congress at Dehra Dun.

Although a measure of protection was afforded to our forests in the past by their own inaccessibility and inhospitable nature, scientific forest management did not come to be introduced in the country until the middle of the nineteenth century. India enjoyed the distinction of being the first country to have enunciated its forest policy way back in the nineties of the last century. The progressive realization of the importance of forests in the economic and the physical field, and the revolutionary changes which had taken place in the political field during the interval which had elapsed led, however, to a re-enunciation of the National Forest Policy of India in 1952. The new policy takes into account the relentless pressure on forests to meet the needs of an ever-increasing population for food, fuel and fodder. No longer are forests to be regarded as an inexhaustible reserve for the extension of agriculture in quest of food. The intrinsic right of forests to occupy land permanently for their protective and productive functions has been accorded special recognition in our national economy. This has been done, I am happy to record, with a singular unanimity of opinion of men who matter. Earnest efforts are afoot to step up the proportion of land under forests where it is deficient. The importance of forests in mitigating the rigours of climatic conditions in this

tropical region, their function in the conservation of soil and moisture, the part they play in the development of industry, communications, river valley projects and their hitherto unsuspected role in National defence, have come to be better understood and appreciated. Forestry in India is no longer regarded as a mere handmaid, but a foster-mother of agriculture. Forests have been accepted as essential to maintain and increase the productivity of agricultural land by providing an alternate fuel to divert the cowdung manure from the village hearths to village fields to replenish their fertility. The importance of treelands in the rural economy of a region where agriculture constitutes the mainstay of the vast bulk of population needs no emphasizing.

It will be seen that the forest development in India has followed a pattern which is none too unfamiliar in other tropical lands. It is to be hoped that our experience in the particular field will provide an instructive background for discussions on tropical forestry.

India's National Festival of the Trees, *Vana Mahotsava* deserves here more than a passing mention. Conceived against the background of the sacred import of our forests which once covered the land and cradled the Aryan civilization, a countrywide drive for the planting of trees was first organized in July, 1950. Ever since then, during the first week of July every year, everyone from the President of the Republic, down to the humble peasant, associates himself with this festival by planting a tree. The affection for, and interest in trees is sought to be inculcated among the masses and more particularly among the youth of the land. Educational institutions have come to play an important role in popularizing this festival. It was at the instance of India that the resolution on the World Festival of the Trees came to be adopted at Rome in 1951 by the F.A.O.

As a matter of fact the basis on which international co-operation in forest management is to be sought for must needs be regional rather than a global. Countries with common problems would naturally evolve a common programme requiring for its execution a common effort. Only the fundamental policies of various regions lend themselves to an integration on a global basis.

I take this opportunity of wishing God-speed to the deliberations of the forthcoming Congress. I sincerely trust that it will provide a forum for the exchange of experience, an opportunity for the provocation of thought and engender an *esprit de corps* among the Foresters of the World to whom I extend a cordial invitation to this ancient land, – the land of Buddha and Gandhi.

Shri Amrit Lal Ji Yadava, Minister for Forests,
Government of Rajasthan.

CONQUERING THE ARID WASTES OF RAJASTHAN

BY AMRIT LAL JI YADAVA

Minister for Forests, Co-operation and Rehabilitation, Government of Rajasthan Jaipur

"Ladies and Gentlemen !

"I consider it a good opportunity to be able to speak to you on a subject with which I have been intimately associated for some time. The expansion of the Rajasthan desert has become to-day a grave threat not only to the economy of Rajasthan State but to the country as a whole and is a problem of national importance. From every quarter scientists are sounding grave warnings about the relentless advance of desert-like conditions ; mostly brought about by man himself. The American scientist, Prof. Shaler is certainly right when he says 'The primitive man did not disturb the soil any more than did the animals; but each extension of civilization has widened the field of devastation of the soil until it has now become a question whether human culture, which rests upon the use of the soil, can devise and enforce ways of dealing with the earth which will become the source of their life so that it can support the men of ages to come'.

"There may be conflicting views about the advance of the Rajasthan desert but even a layman is not unaware of the increasing arid conditions in Rajasthan, the western parts of U.P. and in parts of PEPSU and Punjab.

"Three-fifths of Rajasthan, about 80,000 out of a total area of 1,30,000 sq. miles, is dry and mainly under the influence of desert conditions. It includes the whole of Jaiselmer, Jodhpur and Bikaner divisions ; Jhunjhunu, Shekhawati and Torawati portions of the old Jaipur State and Behror and Mandawar Tehsils of the old Alwar State. The desert presents an appearance of a flat country covered in varying degrees with the sand-dunes of all shapes and sizes ranging from 20 to 200 feet in length, producing a landscape which has aptly been described as 'resembling the Atlantic in a severe storm'. Two types of sand-dunes are generally seen – Longitudinal and Transverse. Of these the latter are constantly shifting.

"According to one theory, a major part of the vast sandy tract of Rajasthan has emerged out of the Arabian Sea as a result of geological transformation. The sea is still receding and in the Run of Cutch we can see the desert in the making. This, no doubt, is in contradiction to the archaeological evidence unearthed in the recent surveys conducted in Bikaner, which stand in testimony of the existence of a well developed civilization in this area.

"The chief characteristics of the Rajasthan Desert are extremes of temperature, fierce winds resulting in shifting of sands, scanty rainfall, great depths of water-level and scarcity of water. The soil of the desert is mainly saline and the salinity is of great economic importance. The desert flora is not a varied one but consists mostly of desert loving shrubs and grasses with only a few types of tall trees, the most important of which is *Prosopis spicegera*, popularly known as *Khejra*. This is known as *Jand* in Punjab and *Shami* in Sanskrit. The advance of the desert conditions is largely due to destructive felling of forests, over-grazing of the land, the soil is denuded of its protective covering of roots and grass. There is nothing to hold the soil together so as to conserve the moisture ; and as vegetation diminishes and the natural seed reserves become exhausted, the desert establishes a firm hold and the possibility of reclamation becomes more remote because the wind whirls sway the once fertile top-soil. Soil erosion, like cancer in human body, is eating into the precious earth and shifting sand is encroaching upon the fields and villages.

"The various States of Rajasthan could not afford to do anything substantial towards land reclamation or in checking the spread of the desert, mostly due to the prohibitive cost involved in undertaking such projects. Still, in its own meagre way, and with the limited funds at its disposal, the former Jodhpur State had been planting the desert loving tree '*Prosopis juliflora*' (commonly known as *Vilayati Khejara*) on a large scale. This tree is found all over Marwar and presents by far one of the best solutions to solve the desert problem. The erstwhile Jaipur State had also a scheme of its own aimed at planting different kinds of trees, shrubs and grasses in the arid and semi-arid regions of Shekhawati.

"The problem of desert control has since become an international problem as 4 out of 5 continents of North America, North Africa, Central Asia and Australia, in fact one-third of the surface of the world, are deserts. The international meeting on land utilization recently held in Ceylon has gone into the question of proper land utilization and made certain recommendations. India has already drawn world attention in the matter of 'Arid Zone Research' in a resolution at the Third Session of the UNESCO in 1948 and UNESCO has now a committee for the purpose. The necessity for arresting the onward march of the desert has been widely recognized both by the State and the Central Governments and the latter have formulated their revised National Forest Policy in 1952. A Soil Conservation Board has recently been set up so as to tackle the Nation's most serious problem on right lines. To-day every State of the Nation is thinking in terms of soil and water conservation.

"An *ad hoc* Committee of experts toured the Rajasthan desert in February, 1952 and following its recommendations a Desert Afforestation Research Station was set up at Jodhpur in October, 1952 with its main functions namely :—

1. Study and research of plants already growing in desert and the possibility of introducing desert loving plants from foreign countries ; and
2. Collection of data regarding rainfall, water-levels and wind velocities. The research station is doing good work. They have found out various types of grasses like *Seqan*, *Mandusi*, *Phog*, etc., which are useful as a sand-binder.

"A Central Nursery has already been established at Jodhpur for distribution of plants. Seed stores are being maintained and seeds of desert loving plants, particularly *Prosopis juliflora* are being distributed through the agency of schools, *Tehsils*, *Gram Panchayats* and other institutions.

"The creation of a forest belt in the desert region is already receiving the consideration of the Government. Similarly schemes for shelter belts along the railway lines and along the Nagaur Balotra road are also being drawn up. The Rajasthan Government have also a scheme for the general afforestation and plantation of trees through the agency of the Forest Department and Community Project Centres and for that purpose a number of nurseries all over Rajasthan are being set up by the Forest Department, which is being re-organized and will be manned by trained personnel. With the creation of a Working Plan and Research Branch, the work of drawing proper working plans for the various States and State controlled Forests is being taken up.

"During July, 1953, last year, a new experiment of aerial sowing of seeds was carried out in Rajasthan along a 30 mile long and a half mile wide desert strip in the Barmer District. Due to certain adverse factors the results could not come up to the expectations. An attempt is, however, being made to eliminate these factors in the next year's operations in the coming July so that the experiment may meet with success.

"A peculiar feature of the topography of Rajasthan is that the two portions, to the east and west of the Aravalies, stand in marked contrast to each other – that towards the west

of the Aravalies is desert while that towards the east is fertile, being interspersed with trees and forests. Therefore, while it is our endeavour to plant up the western zone by suitable desert-loving species we are equally concerned in preserving and improving, as best as possible, the rich heritage of forest wealth in the eastern zone.

"The different categories of forests in Rajasthan do not admit of any uniform control or a unified and efficient system of management; because, apart from the State Forests, a great majority of the forests are *jagirdari* which the *jagirdars* have, of late, started exploiting indiscriminately without proper working schemes in their anxiety to earth whatever they can from these forests and thereby to increase the proportion of their compensation payable to them at the time of *jagirdari* abolition which is now merely a matter of a few days. Again there are forests in the private properties of the ex-Rulers and in some, the ex-Rulers have rights of fuel and fodder collection. In the larger interests of the nation and in order that this national wealth is not squandered away, it is necessary that all such forests should remain under State control so that a uniform and efficient system of management may be possible.

"In the desert area the velocity of wind is so high that wind mills can be established to draw water from a depth of 300 feet. In places like Sujangarh water can be had at a depth of 15 feet only. This can be used for afforestation purpose.

"If the big river projects in Rajasthan – the Chambal Project, the Bhakra Nangal Project, the Hari-ke-Patan Project, the Parvati Bund Project – are completed speedily large sources of water-supply will be available and help solve the desert problem to a great extent.

"With the resumption of *jagirs* in Rajasthan, a considerable area of the forests, which had hitherto been subject to uncontrolled and indiscriminate cutting and overgrazing, will also come to be placed under the technical and expert control of the Forest Department; and will be a great contributory factor in averting the spread of desert conditions.

"Before I conclude I would again like to say with all the emphasis that the problem of Rajasthan Desert is not the problem of Rajasthan alone but a time has come when we must recognize it as a big national issue, which should be given priority in nation building plans. With all the sincere and concerted efforts of the Central and Rajasthan Governments and with the close co-operation of you all, I believe we shall be able to meet this challenge of nature and arrest the onward march of desert conditions and in course of time this arid land of the present day will come to be transformed into a rich and beautiful landscape, bringing with it prosperity and happiness to the country".

"JAI HIND".

WILT DISEASE OF SHISHAM (*DALBERGIA SISSOO* ROXB.)

I. Introduction and Host-parasite Relationship

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SUMMARY

This is the first in the series of articles dealing with the wilt disease of shisham, the localities of occurrence of the disease, its symptoms, the fungus causing wilt and its life-history, the occurrence and effects of the fungus on the host. A detailed summary is given at the end.

INTRODUCTION

Dalbergia sissoo is one of the most important timbers of India. The heartwood is strong and durable and is brown with darker figurings for which reasons it is prized for furniture making and general constructional work and is the chief timber used for gun carriage parts in India. It also makes excellent veneers. Shisham grows naturally and is also artificially regenerated on alluvial soils and is widely distributed on riverain beds and the sub-Himalayan tract from Indus to Assam and in the Himalayan valleys up to about 3,000 feet. Shisham grows gregariously and forms a forest, either pure or mixed with *Acacia catechu*, on the new alluvium formed of deposits of sand, boulders, etc., in the beds of rivers of the sub-Himalayan tract and outer Himalayan valleys. The species comes up quickly on virgin soils exposed during land slips and is one of the first colonizers of such soils. Shisham prefers a sandy soil and becomes stunted on clay. Aeration is important in the healthy development of roots. Given irrigation it is a very successful species for reclaiming sandy wastes and converting them into valuable plantations like the irrigated plantations of West Punjab. Artificial plantations of shisham are raised under the taungya method in the Uttar Pradesh and the species is largely used as an avenue tree along roads and canal banks in Western India.

In the plantations, a mixed crop is preferred and silviculturally desirable. The reasons for the admixture is that shisham being a light demander has a tendency to form an open crop which does not adequately protect the soil. Shisham is also liable to suffer from root diseases and if a disease breaks out in a pure crop, its spread is rapid from tree to tree and nothing may be left of the crop at the end. In mixed plantations, however, the associates of shisham may be immune to the diseases of shisham and if a disease breaks out in a plantation, it becomes restricted and does not assume an epidemic proportion. The associates of shisham are so chosen that they yield some important forest produce. In the taungyas of Uttar Pradesh, therefore, shisham is grown in admixture with economic species like semul (*Bombax malabaricum*), babul (*Acacia arabica*), khair (*Acacia catechu*), bamboo (*Dendrocalamus strictus*) and other species.

Shisham is a large deciduous tree growing up to 8 feet in girth and 100 feet in height. The rotation of the natural crop in the Uttar Pradesh is about 60 years though in irrigated plantations of the West Punjab, it is much shorter being about 20 years. The leaf-fall occurs in November–December depending on the climate and the pods begin to be shed from this time though a large number remains on the tree till April. New leaves begin to appear in March followed soon after by the development of flowers and then pods. The pods remain attached to the tree for some months and take a long period in ripening. The tree possesses a long, thick tap root and several surface laterals within 2 feet or so from the surface. The latter may run parallel to the surface or running horizontally for a distance penetrate into the soil.

The surface laterals are richly branched and nodules, which characterize species of Leguminosae, are present in large numbers on them (Pl. 1, Fig. 1).

16 fungi have been recorded on shisham by Butler and Bisby (1931). Most of these occur on dead wood and branches or else are of no economic importance. Troup (1921) stated that widespread mortality of shisham in many localities in the Punjab and Uttar Pradesh is due to attack by *Ganoderma lucidum*. Sporophores of this fungus as well as that of *Ganoderma applanatum* and *Polyporus gilvus* are conmmonly found individually or in association on butts of mature shisham trees (Bagchee and Bakshi, 1950). These three Basidiomycetes are root parasites and also behave as wound parasites and are responsible for considerable root and butt rot. Sapwood and to a limited extent heartwood are attacked in which the fungi produce a white fibrous rot. The affected trees continue to live for some years until their roots become considerably decayed when the trees are blown down by wind. Besides these, a species of *Phoma*, so far unrecorded and believed to be a new species, is found to be parasitic on green pods and seeds and also on green twigs. The pycnidia of the fungus are common on these plant parts. It remains to be proved that the parasite *Phoma* could be pathogenic, but the fungus does not appear to cause any disturbance in the normal germination and growth of the seedlings from the infected pods and seeds.

In contrast to the diseases of shisham caused by *G. lucidum*, *G. applanatum* and *P. gilvus* which do not kill the affected trees immediately, a wilt disease of shisham is of widespread occurrence, both in the natural forests and taungyas, in the Dehra Dun and Saharanpur districts, in Uttar Pradesh, which kills the trees rapidly within a few months after the symptoms of wilt become evident on the crown. The wilt disease which was reported by Bagchee (1945) as caused by *Fusarium* sp., has since been proved to be soil borne. The soil has a considerable influence on the incidence of root diseases. The soil should not be looked upon as a dead substratum of sand, loam, clay, etc., resulting from weathering of rocks but as a living system where numerous microorganisms, namely, fungi, bacteria, actinomycetes, protozoa, insects, etc., are in a state of dynamic biological equilibrium. The microbial population is in a state of continuous change under various natural and artificial modifications of the soil. The microorganisms may have an associative or an antagonistic effect on the soil-borne plant pathogen. The study of soil-borne diseases thus involves a triple biological reaction, that between the host plant, the parasite and the general soil microflora, under varying conditions of soil texture, soil moisture, soil reaction, available soil nutrients, etc. A satisfactory explanation of the development of the disease under such varied conditions becomes a difficult task. Investigations are in progress to analyse all the factors with a view to evolving control of the wilt disease. The results will be published in parts of which the present one is the first in the series.

HOST-PARASITE RELATIONSHIP

Symptoms of wilt—Wilt in the shisham occurs in trees of about 15–25 years of age and plants in the seedling and sapling stages are not found to be attacked by the disease. The disease is observed both in the natural forests and artificially planted stands in taungyas, in Dehra Dun and Saharanpur districts, Uttar Pradesh. Wilting starts during April–May after the new flush of leaves appears but is common between June and September during and immediately after the rains. The disease is systemic in that the entire tree shows symptoms of attack. In the early stages, an affected tree is characterised by drooping leaves and branches due to loss of turgor. The leaflets turn yellow, dry up and eventually drop off rendering the branches increasingly bare. The entire tree becomes 'thin' in contrast to the adjoining densely clothed green trees (Pl. II, Fig. 3). Death of the affected trees is rapid and occurs within 4–6 months after the crown shows the symptoms of wilt.

The roots of a wilted tree are adversely affected. They become devoid of the finer branches and rootlets which characterise healthy roots. Nodules which occur in large numbers

on the healthy roots are rare or absent on the roots of a wilted tree. On splitting the diseased roots, the bark and the outer sapwood exhibit a well defined pinkish brown (containing various shades of 'sorghum brown', 'army brown', 'light seal brown' according to Ridgway, 1912) stain (Pl. III, Figs. 4 and 5) and though the stain is mostly restricted in this region, it may rarely penetrate into inner sapwood. The heartwood is free from the stain. The stain is also present in the outer wood of the stem up to varying distances from the ground depending on the severity of the disease. In late stages of wilt, the stain has been found to extend along the stem up to a height of 10 feet from the ground.

In addition to the above symptoms, the wilted trees may exhibit decay in the roots by more than one species of Basidiomycetes. The decay fungi, however, are not constantly associated with all wilted shisham, and many wilted trees may be found to be free from attack due to Basidiomycetes.

Causal Organism—(*a*) Isolation—The roots of wilted trees were exposed and studied *in situ* to record the initiation and progress of the disease. For isolation, the roots were cut into convenient lengths and split lengthwise so that no part of the chisel, knife or hammer which were used for splitting touched the fresh surface of wood thus exposed. Small slivers of wood (inocula) were cut and transferred aseptically into agar in Petri dishes. Such a method dispensed with the need for surface-sterilization of the inocula with disinfectants like mercuric chloride, etc. The Petri dishes were incubated at 25°C. for 3–4 days or longer, if necessary, after which period the fungi growing out from the inocula were examined.

Numerous isolations were attempted from roots and basal parts of the stem of wilted trees, both from the bark and outer sapwood containing the stain and also from unstained inner sapwood and heartwood. One hundred per cent of the isolations from stained wood yielded the only fungus *Fusarium solani* in culture. The thick roots like the tap root and also the basal portion of the stem did not yield any fungus from the inner sapwood though *F. solani* was isolated from outer sapwood of these roots, especially from the stained region. From thinner roots like the laterals, all isolations from outer sapwood yielded *F. solani* while the fungus grew out from nearly 50 per cent of the isolations from inner sapwood. No fungus grew out from isolations from the heartwood.

In some wilted trees, the roots exhibited a 'white' rot in which zone lines were sometimes present. Isolations from these roots yielded, in addition to *F. solani*, two Basidiomycetes *Polyporus gilvus* and an unknown one, which possesses only clamp connections in culture. *P. gilvus* produced 'white' and spongy rot in which light yellow zone lines were present and in advanced stages of decay the wood becomes very soft and light. The fungus developed abundant sporophores on butts of affected trees. The unknown Basidiomycetes produced a 'white' rot in the wood but the decayed wood was firm. This fungus did not develop any sporophore on the host nor any fruiting structures developed in culture. The association of the Basidiomycetes with wilted shisham was occasional and was in addition to infection of the roots and butts of trees by *Fusarium solani*. Sporophores of *P. gilvus* commonly develop on butts of shisham unaffected by wilt disease and such affected trees continue to live for years until their roots become considerably decayed and the trees unable to get any foot-hold in the soil are liable to wind throw. It can, therefore, be concluded that *Fusarium solani* was constantly associated with the wilted shisham and the fungus was consistently isolated from roots of wilted trees. The Basidiomycetes may sometimes attack roots and cause root and butt rot but the fungi are not responsible for the wilt disease of shisham.

(*b*) Identity—*Fusarium solani*, which was consistently isolated from the roots of wilted shisham, was established in pure culture by making monospore (monoconidial) isolations of the fungus. In making single spore cultures, a small loop (about 1 mm. square) of the inoculum from the parent polysporous culture which was 4–5 days old was aseptically

transferred to a sterile test tube containing 10 c.c. of sterile tap water. The test tube was shaken and a conidial suspension was obtained, 2 c.c. of which were taken by means of a sterile pipette and poured over a solidified layer of malt agar on a Petri dish. The conidial suspension was spread over the agar by tilting the Petri dish and the excess water was drained off. After incubation for about 18 hours, the Petri dish was examined directly under the low power objective of a microscope by removing the upper lid. The high power objective of the microscope was replaced by a dummy one. It was observed that conidia were widely scattered on the plate and a single germinated conidium was located in the field. The dummy objective, after sterilization, was turned on and the agar containing the germinated conidium was cut out. The low power objective was turned on again to confirm that only one conidium was included in the agar that was cut out after which it was transferred to an agar slant and a monoconidial or monospore culture was thus obtained. Many monospore cultures were prepared all of which had similar growth and cultural characters. Monospore cultures were grown on slant tubes of malt agar, potato-dextrose agar, oatmeal agar, Brown's synthetic agar and Czapek's agar which were kept at 24°C. in the dark. Cultural characters were noted at one-week interval up to 4 weeks. Characters of conidia were noted when cultures were 2-weeks old. Chlamydospores were rare or did not develop at all at this stage so that older cultures, about 4–5 weeks old, were examined for their occurrence. The results are tabulated below.

TABLE 1.—*Macroscopic and microscopic characters of Fusarium solani (monospore cultures) on different media*

Characters	Malt	Potato-dextrose	Oat-meal	Brown's synthetic	Czapek's
MACROSCOPIC					
Mat	Floccose to sub-felty, thin felty with age, advancing zone indistinct appressed	Floccose to loose cottony advancing zone indistinct	Downy, thin felty with age, advancing zone appressed	Cottony to cobwebby, advancing zone cottony distinct	Dense woolly to cottony felty, thick felt with age advancing zone woolly
	Growth (radial) 1·8 cm.	Growth (radial) 2·3 cm.	Growth (radial) 2·6 cm.	Growth (radial) 1·8 cm.	Growth (radial) 2·6 cm.
Colour	White	White, in which black shade 'deep mouse gray' appears later	White	White	White turning 'light buff' when old
Sporodochia ..	Rare	..	..	Rare	Rare
Pionnotes	Present, large	Present	Present	Present	Present, large
MICROSCOPIC					
Microconidia					
(text-Fig. 1*b*)					
0-Septate ..	4·5–14·5× 2·3–5·7μ abundant	5·7–12·1× 2·8–5·7μ abundant	5·7–14·6× 2·5–4·9μ abundant	7·7–14·2× 2·6–4·5μ abundant	3·5–12·8× 2·8–4·5μ abundant
1-Septate ..	12·5–17·3× 4·3–5·7μ abundant	11·4–17·0× 4·3–5·7μ abundant	12·0–16·3× 2·8–5·7μ abundant	12·8–17·2× 2·8–5·7μ abundant	4·3–15·6× 2·8–4·3μ abundant
2-Septate ..	..	..	..	..	9·9–12·8× 2·6–3·5μ rare

(*contd.*)

TABLE 1.—*Macroscopic and microscopic characters of Fusarium solani (monospore cultures) on different media*—(concld.)

Characters	Malt	Potato-dextrose	Oat-meal	Brown's synthetic	Czapek's
MICROSCOPIC Macroconidia					
(text-Fig. 1*a*)					
1-Septate ..	17·3–24·1× 3·9–5·8μ abundant	17·0–24·1× 4·3–5·7μ abundant	16·6–24·1× 4·3–5·7μ abundant	17·0–24·8× 3·5–4·9μ abundant	12·8–22·7× 2·8–4·5μ abundant
2-Septate ..	21·7–23·9× 4·3–5·7μ rare	20·6–26·9× 4·3–5·7μ abundant	20·9–26·9× 4·3–5·8μ abundant	20·6–29·8× 4·3–4·9μ rare	21·3–28·4× 3·5–4·9μ abundant
3-Septate ..	25·6–34·1× 4·5–5·8μ abundant	24·1–35·5× 4·5–6·8μ abundant	25·6–36·9× 4·3–5·9μ abundant	30·9–41·2× 4·3–6·1μ abundant	24·1–32·7× 3·9–5·7μ abundant
4-Septate ..	..	..	..	35·5–42·6× 3·9–6·4μ Not abundant	..
Chlamydospores					
(text-Fig. 1c-*e*) ..	7·8–14·6× 6·1–9·9μ abundant in old cultures only	5·1–10·2× 4·4–10·2μ abundant in old cultures only	7·3–10·6× 5·7–9·2μ abundant in old cultures only	7·1–12·8× 5·7–11·6μ in both young and old cultures	5·8–9× 5·1–7·6μ abundant in old cultures only

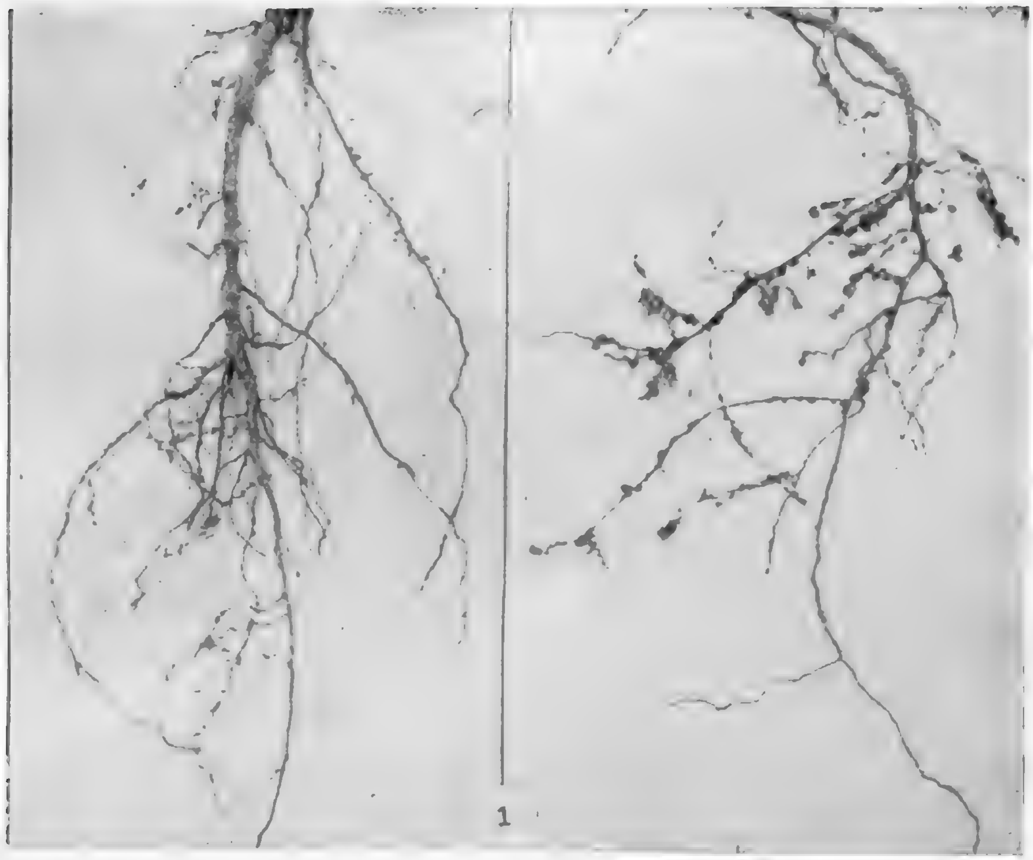
Chlamydospores are both apical and intercalary. They have a thick wall which may be smooth or with regular or irrigular relief (text-Fig. 1c-e). Conidia of *F. solani* are grouped together in heads which develop within 2–3 days in the culture and are formed in large numbers (Pl. I, Fig. 2). The conidia in the head are at first embedded in a liquid drop which drys up with age. Though such heads are by no means characteristic of the species only, their presence in platings from roots of wilted trees served as a ready means of rapid identification of the fungus when isolations were done on a large scale. The identity was confirmed in many cases by studying other characters of the fungus in detail.

The shisham-wilt fungus is identified as *Fusarium solani* (Martius) Appel and Wollenweber emend. Snyder and Hansen.

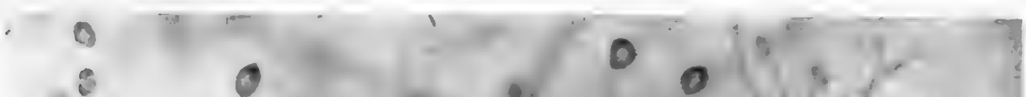
It may be mentioned that a pathogenic form of *Fusarium solani* (Martius) Appel and Wollenweber forma *albizzae* has been described by Bagchee (1954). The fungus occurs in New Forest and its neighbourhood and produces pit cankers on the stem of *Albizzia procera.*

Fusarium solani within the host—Unlike the vascular-wilt parasites which are confined to the vascular tracts once they enter the host, the hyphae of *F. solani* are abundant in all the tissues of the root including the vessels and the fungus thus possesses a less specialized growth habit than the vascular-wilt pathogens. Inside the wood, the hyphae of *F. solani* are hyaline, much branched, 1–2μ broad. In its effect on the host, *F. solani* behaves like other vascular parasites in that the hyphae clog the vessels and other tissues of the root. The fungus travels up the lateral roots into the tap root and thence into the stem. In severe cases of wilting the visible stain in the wood due to *F. solani* has been found to extend up to 10 feet or so from the ground. Due to clogging of the vessels and adjoining tissues in the sapwood, especially in its

PLATE I



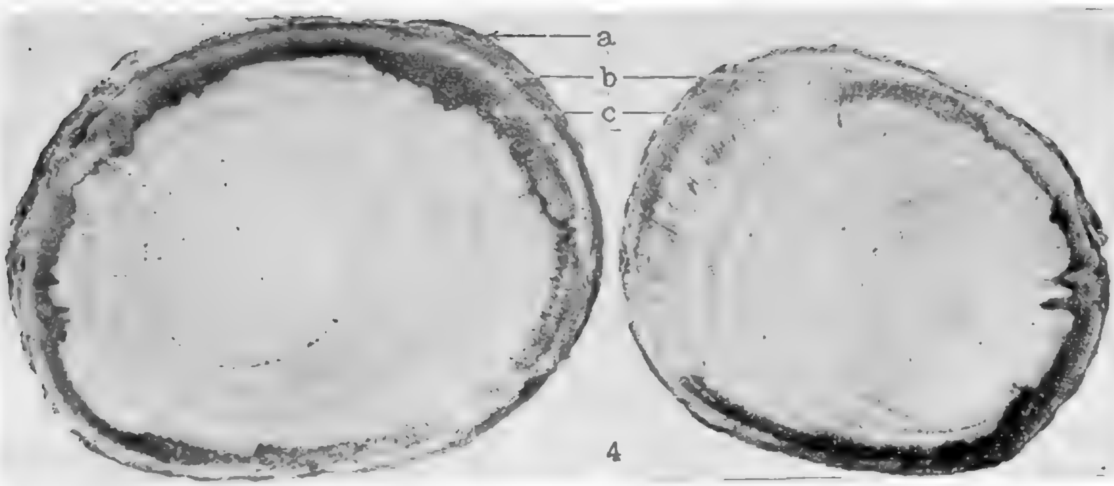
1



2

PLATE II

PLATE III



4

5

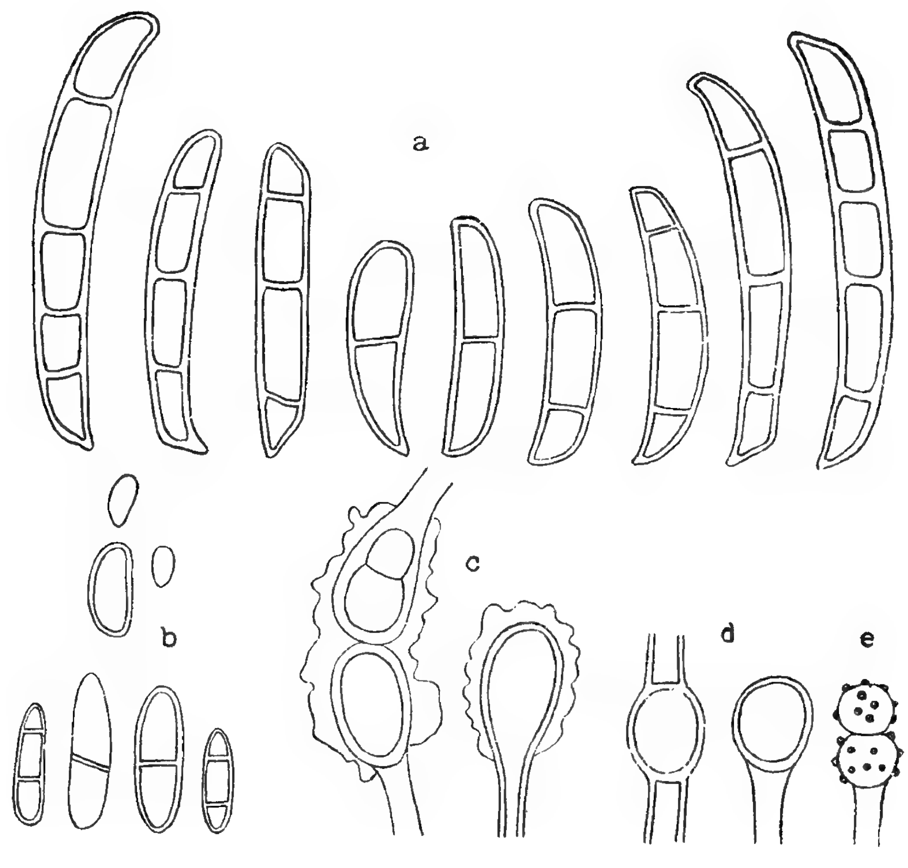


FIG. 1

outer region, through which the sap-flow mainly occurs, the water supply to the crown is stopped or at any rate considerably reduced, as a result of which the crown wilts. It may be mentioned that for the visible manifestation of wilt in the crown, a certain proportion of the root system must be invaded by the fungus. Many apparently healthy shisham often show a small percentage of their roots invaded by *F. solani*. Such trees, in the initial stages of attack by the fungus, do not exhibit any symptoms of wilt on the above ground part because the crown obtains the necessary water supply from the healthy roots which occur in larger proportion than the diseased roots.

Cause of stain in wood—Though circumstantial evidence suggested that *Fusarium solani* was responsible for the pink stain in the wood, an experiment was set up to find out the effect of the fungus on healthy wood. For this, the sick soil was collected underneath wilted shisham and taken in sterilized closed glass jars. Healthy roots of shisham were dug out and washed in running water to remove the surface soil. Roots about 0·5 inch thick were selected, cut in 1–2 inch lengths, surface sterilized in 0·01 per cent mercuric chloride and later washed in repeated changes of sterile distilled water. A large number of these root bits were plated out to confirm that no fungus grew out from them and that they were healthy. Some root bits were split longitudinally to be sure that the wood did not exhibit any stain. The remaining root bits, 24 in number, were then buried in the sick soil in the jars. After a month the root pieces were harvested and washed in sterile water to remove the adhering soil. Small slivers of wood from within the roots were plated out on agar and it was observed that isolations from all the root-bits yielded *F. solani* in culture. On splitting the root-bits lengthwise, the wood exhibited the characteristic pink stain due to *F. solani*. This proves that *F. solani* which was present in the sick soil attacked tne healthy roots and caused pink stain in the wood.

SUMMARY AND CONCLUSIONS

1. A wilt disease of shisham (*Dalbergia sissoo*), an important timber species, is described. The disease has been observed both in natural forests and artificial plantations in the Western Uttar Pradesh.

2. Some silvicultural characters of shisham are described since a knowledge of these will aid in understanding the incidence, development and control of wilt disease.

3. Diseases of shisham which have already been reported are referred to.

4. Only mature trees over about 20 years in age suffer from the wilt disease. The symptoms are systemic accompanied by yellowing and drooping of leaves and branches. The roots of these trees are severely affected. The nodules and slender branches on roots are lost. Infected trees die within a few months after symptoms of wilt on the crown become evident.

5. The fungus causing the wilt disease is soil borne and invades the tree through the roots and travels a short distance along the stem. The sapwood, particularly the outer region, is attacked and a well defined pinkish brown stain is produced. The hyphae clog the vessels and tissues in the sapwood and stop the flow of sap from the roots to the crown which wilts as a result.

6. Wilting of the crown does not start until a certain proportion of the roots of a tree has been invaded by the fungus, at which stage the remaining healthy roots are not able to meet the necessary water requirement of the crown. Thus when a crown starts wilting, it indicates an advanced stage in the development of the disease.

7. *Fusarium solani* has been found to be constantly associated with wilted trees from the infected tissues of which, particularly the roots, the fungus has been consistently isolated,

8. Healthy but cut root pieces of shisham were quickly infected by *F. solani* when such roots were buried in a soil naturally infested by the fungus. From these infected root pieces, *F. solani* was re-isolated.

9. A pink stain developed in the wood of healthy root bits artificially infected by *Fusarium solani*, proving that the fungus is responsible for the pinkish brown stain in the sapwood of wilted trees.

From all the evidence given above, it is concluded that *Fusarium solani* is responsible for the wilt and death of shisham.

10. The cultural characters of *F. solani*, both macroscopic and microscopic, are described.

11. The roots of wilted trees are sometimes attacked by *Polyporus gilvus* and an unidentified Basidiomycete in addition to infection by the wilt-fungus, *Fusarium solani*. Sporophores of *P. gilvus* and *Ganoderma lucidum* are also found on butts of healthy shisham. It is concluded that the association of the Basidiomycetes with wilted trees is incidental. These wood-rotting fungi cause root and butt rot but the affected trees continue to live until their roots become decayed and the trees get wind blown.

We are indebted to Mr. C. R. Ranganathan, I.F.S., President of the Institute, for suggesting the problem and helpful advice and to Dr. K. Bagchee, Mycologist, for keen interest in the work. Sincere thanks are due to Dr. W. L. Gordon, Plant Pathologist, University of Manitoba, Manitoba, Canada, for identifying the culture of *Fusarium solani* sent to him.

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DESCRIPTION OF PLATES I–III

PLATE I

FIG. 1.—Healthy roots of shisham showing branching and nodules. (× 3/5).

FIG. 2.—*Fusarium solani* in culture showing conidial heads, some of which are enclosed in a liquid drop. (× 135).

PLATE II

FIG. 3.—A natural forest of shisham showing a tree (marked ×) in advanced stages of wilt which is nearly leafless in contrast to the neighbouring densely clothed trees.

PLATE III

FIG. 4.—Transverse sections of the roots of a wilted shisham showing bark in surface view (a), unstained bark in section (b) and stained outer sapwood (c). (× 4/5).

FIG. 5.—Longitudinal sections of the roots of wilted shisham showing unstained bark (a) and stained outer sapwood (b). A zone line is present in the sapwood of the root shown on left. (× ½).

EXPLANATION OF TEXT FIGURE

FIG. 1.—*Fusarium solani* a, macroconidia ; b, microconidia ; c, chlamydospores, apical and intercalary on Brown's synthetic showing thickenings on the wall ; d, apical and intercalary chlamydospores on oat agar showing smooth wall ; e, chlamydospores with regular but discontinuous thickening on wall. (all × 1300).

POECILONEURON INDICUM, BEDD., ITS SILVICULTURE AND MANAGEMENT

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Local names—Kanarese—*balagi, baliga, ballagi, kirballi, balige, bliuna* ; Tamil—*puthan-kolli, pathang-koli* ; Malayalam—*vayila, puthankalli.*

Description—A large evergreen tree with a clean straight bole which attains a height of 120 feet or over (Fig. 1) and a girth of 8 to 10 feet or more at breast height. The sapwood contains a yellowish, thick juice which is a general characteristic of the family Guttiferae to which the tree belongs. The older trees are often buttressed. A very characteristic feature of this tree, and one which readily distinguishes it at first sight from others in the evergreen forest, is the presence of massive, stilt shaped roots (Fig. 2). These roots emerge generally at heights of 2 to 5 feet from the ground and look at first like the aerial roots from a banyan tree complete with their reddish-brown root caps. At first very thin, they grow downwards to the soil describing a broad curve and on entering it they become stouter and stronger and as the tree gets older they often flatten out into a buttress shape. The trunk of a full grown tree, therefore, often looks as if supported on a number of arched logs. The bark of the adult tree is ½ inch or more thick and varies generally from dark brown to dark grey in colour. Leaves are opposite, stipulate, petiolate, elliptic acuminate, 3½ to 10 inches by 1½ to 2½ inches. The leaf surface is smooth and coriaceous with an indefinite number of equidistant, close-set, almost parallel lateral veins, which are not prominent. The lateral veins are joined at right-angles by numerous, less conspicuous smaller veins. The copious, yellowish-white sweet scented hermaphrodite flowers are placed in pyramidally spreading, terminal panicles, which are 4 to 6 inches long. The flowers are about ¾ inch in diameter. Calyx has 4–5 imbricate sepals. Corolla consists of 5 to 6 petals and is contorted or imbricate in bud. Stamens number 16 to 20 and are free or slightly connate at the base ; filaments are short or absent. Anthers are basifixed, narrow-linear, erect. Each anther-cell consists of numerous, superposed compartments. Ovary is superior, two celled, with two filiform styles and two ovules in each cell which ascend from the base. Fruit is an avoid, one celled, one-seeded capsule, 1 to 1½ inches in diameter ; debiscence is septicidal. Seed is erect and exalbuminous. Cotyledons are fleshy and the radicle minute and inferior (Kadambi).

Varieties of Poeciloneuron indicum—There are two varieties of *Poeciloneuron indicum* which exhibit differences in morphological, anatomical and habitat characters : one is commonly called 'white variety' the other 'black variety'. The latter is often gregarious in the Bhadra river source valleys (Fig. 3). There are no noticeable differences in their floral parts which would justify their elevation into separate species ; the only difference, and that a minor one being that, in the 'black' variety the panicles are borne on relatively shorter stalks. Among the morphological and other characteristics which enable one to distinguish a tree of the 'white' from that of the 'black' variety in the field are the following (Kadambi, 1942) :—

"Black" variety	"White" variety
Adult leaves	
3½ to 6 inches long, dark green, secondary and tertiary veins less regularly arranged than in the white variety.	4 to 10 inches long, lighter green, with close-set regular parallel lateral veins.

"Black" variety	"White" variety
Bark	
Black blotches on a grey-green ground colour when young, the blotches running into one another and often turning dull rusty brown with age	No conspicuous dark coloured blotches; bark turns dark greyish with age.
Bole-form	
Relatively short and branchy, often conspicuously fluted at the base (see Fig. 4), less regular in cross-section	Tall, cylindrical, branchless boles up to considerable heights.
Stilt roots	
When young more conspicuous and anastomosing and having finer ramification; bole of older trees buttressed with buttresses often running up to considerable heights on the stem (Fig. 4).	Stilts fewer but relatively stout, flattening out with age (Fig. 5).
Seed and seedling	
Testa darker green, cotyledons generally two but sometimes three, seedling develops at first a very powerful tap root which descends deep down into the ground and anchors the seedling firmly in the rocky soil. Hypocotyl generally strongly arched, bearing epigeal cotyledons which last for more than one season. Annual shoot dies back for one or two seasons, the nourishment then required being partly met from the large, green cotyledons.	Testa relatively light in colour. Cotyledons almost always two. At first a tap-root is formed which, on failing to reach the mineral soil, results in the death of the seedling. Cotyledons rarely last for more than one season. Seedlings are relatively less drought resistant and die off at the end of the first season if they remain inadequately established.
Timber	
Dark brown, often approaching jet black, heavier and stronger; seasons with less degrade.	Lighter shade of brown, hardly ever approaching black, less hard and seasons with more heavy degrade.
Transition from heartwood to sapwood abrupt. Twisted fibre and interlocked grain in wood more common.	Transition from heartwood to sapwood more gradual.
Habitat	
Generally fond of stream banks, sometimes thronging the beds of seasonal streams and capable of growing with at least a portion of its root system submerged in water during the rainy season.	Grows best on steep, well drained hill slopes facing the Arabian sea.

Distribution and Habitat—The tree is endemic in the evergreen forests of the Western Ghats from South Kanara and Gersoppa (Mysore) southwards to Malabar, Anamalais and Travancore-Cochin (Fig. 6); but there are breaks in the continuity of distribution in the Hassan ghats of Mysore and in the ghat forests of Coorg and parts of Wynaad. Bourdillon mentions that the tree is common in the south of Travancore at elevations of 1,000 to 3,000 feet but less common in the north, and that it is generally found in clumps growing on the wind-swept ridges.

FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIG. 5

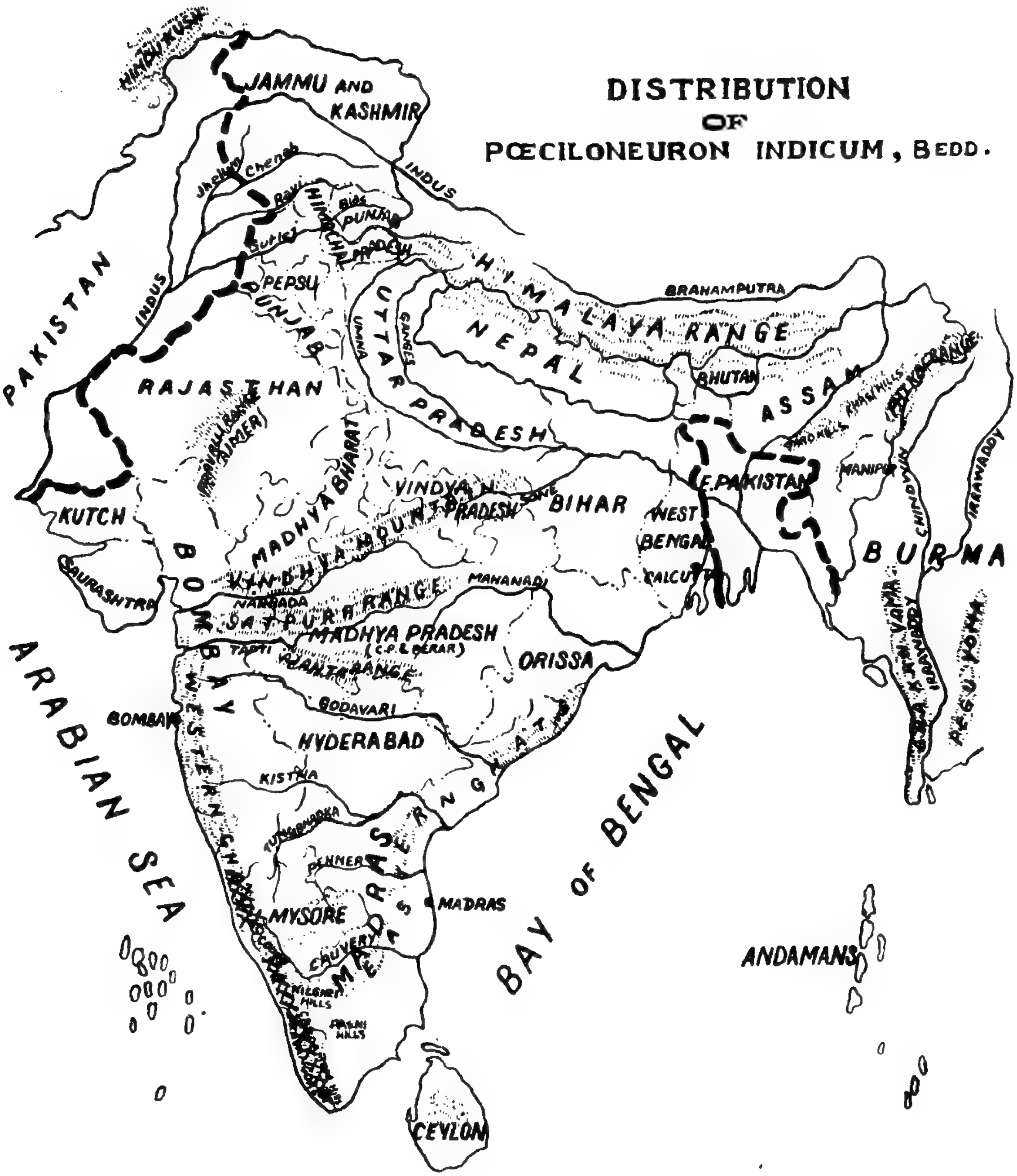
DISTRIBUTION
OF
PŒCILONEURON INDICUM, BEDD.
JAMMU AND
KASHMIR
INDUS
PAKISTAN
RAJASTHAN
PEPSU
PUNJAB
HIMALAYA RANGE
NEPAL
BHUTAN
ASSAM
UTTAR PRADESH
BRAHAMPUTRA
E. PAKISTAN
MANIPUR
BURMA
KUTCH
SAURASHTRA
MADHYA BHARAT
VINDHYA PRADESH
BIHAR
WEST
BENGAL
CALCUTTA
VINDHYA MOUNTS
SATPURA RANGE
NARBADA
MAHANADI
MADHYA PRADESH
(C.P. & BERAR)
ORISSA
TAPTI
AJANTA RANGE
GODAVARI
BOMBAY
HYDERABAD
KISTNA
TUNGABHADRA
PENNER
MYSORE
MADRAS
CAUVERY
NILGIRI
HILLS
PALNI
HILLS
CEYLON
ARABIAN SEA
BAY OF BENGAL
ANDAMANS
IRRAWADDY
CHINDWIN
PEGU YOMA

FIG. 6

In Mysore state the tree is confined to evergreen forests of the Western Ghats of Shimoga and Kadur districts and extends as a more or less continuous belt from the foot of the Kodachadri hill southwards into the Bhadra source valley in South Bhadra state forest which is the richest tract. Between Kodachadri and Gersoppa which is the northernmost limit of the evergreen forest zone in the State, the tree is very sparse and occurs only in isolated patches in Karni and Govardhanagiri forests ; it is absent from the Jog forest. South of the South Bhadra state forest it is again found in the form of isolated patches in Balur forest which is its southernmost limit in the State.

The following is a list of the State forests in which the tree is found in Mysore State. Commencing from the north, they are :—

	Forest	Area sq. miles
1.	Govardhanagiri (opposite Bhatkal harbour)	45·30
2.	Karni	28·50
3.	Kodachadri	8·10
4.	Chakra	3·50
5.	Kilandur	25·50
6.	Varahi	9·97
7.	Manibyle	2·71
8.	Agumbe	20·17
9.	Balehalli	8·27
10.	Narasimhaparvata	26·61
11.	Tungabhadra	77·87
12.	South Bhadra	34·63
13.	Balur	31·46
	TOTAL ..	322·59

The tree thrives at altitudes varying from 1,000 to generally 3,000 feet or occasionally to 4,000 feet (Troup) though the best dimensions are attained by it below 3,000 feet. In Mysore State the tree is generally confined to a thin strip of vegetation 5 to 6 miles wide covering the crest of the Western Ghats, but it also descends over the ghat head into the adjoining forests of South Kanara district, Madras, where it is often very abundant on the steep western slopes exposed to monsoon winds. The tree prefers hill slopes to flatter country and attains its best dimensions in the wind swept valleys or on the undulating ground found among the hills facing the Arabian Sea.

Rock, soil and climate—The underlying rock formation consists of metamorphic schists and crystalline gneiss with granite and quartzose intrusions. Extensive areas of surface laterite cover the rock to various depths, frequently 20 feet or more. The rock decomposes on weathering into a pale, cankered easily friable material which finally reduces to a yellow or red felspathic clay or loam. There are several variations of this material both in colour and texture. The weathering process has been followed by infiltration of iron compounds. This loam or clay is able to support a first class forest of tall, straight boles. Into it the organic humus diffuses gradually. It is such soil that *Poeciloneuron* loves.

In the natural habitat of the tree the absolute maximum shade temperature varies from 90° to 98°F., the absolute minimum from 50° to 60°F. The maximum is higher at the lower limit of its altitudinal distribution and the minimum is also lower at the upper limits of

its growth at 4,000 feet. The rainfall varies within wide limits, from about 80 to 350 inches or more. Most of the rain falls, however, within a few months in the year, between June and September. In this season rain comes in torrents, the atmosphere is surcharged with moisture and the sub-soil water-level rises to the surface and wells overflow. During the remaining period of the year comparatively dry conditions prevail. Most of the forest streams run dry, the air is relatively dry and hot and difficulty is sometimes experienced for drinking water as water fails in many wells.

Forest types and associate tree species—The tree is a native of the forest type "Western Tropical Evergreen" (Champion's 1a. C 3) which is found in the Western Ghats wherever moisture conditions are adequate. The abundance of the seedling regeneration of this tree combined with the vigour with which the species is able to withstand the keen competition for space which prevails in these evergreen forests indicates that the tree enjoys in the forests its optimum demands on the factors of growth, both climatic and edaphic. The remarkable abundance of the tree in every age class of the mixed forest crop consisting of over a hundred tree species indicates the virility of this tree.

The following are a few typical localities where the tree occurs in abundance and its associates in them :—

(1) *Agumbe-Kilandur Zone ; Shimoga and Sagar divisions, Mysore State*—Important trees of this zone are :—*Poeciloneuron indicum, Dipterocarpus indicus, Mesua ferrea, Hopea parviflora, Calophyllum elatum, Palaquium ellipticum*, and many others. (W. P. Manual, Mysore, 1944, p. 129).

Three major associations of tree species within which *Poeciloneuron* figures prominently are :—(i) *Poeciloneuron – Mesua* association at the crest of the ghats with *Lansium anamalayanum* in the underwood. (ii) *Poeciloneuron – Dipterocarpus* association further inland with *Humboldtia brunonis* in the underwood. (iii) *Poeciloneuron – Palaquium* association with *Poeciloneuron indicum* and *Palaquium ellipticum.*

(2) *Tunga-Bhadra source valleys, Chikamagalur division, Mysore*—(i) *Heggan valley – Poeciloneuron indicum* (20 per cent), *Palaquium ellipticum, Dipterocarpus indicus, Mesua ferrea* and many others including species of *Garcinia, Myristica*, etc. (ii) *Valley of the Tunga river source : in Tungabhadra forest – Poeciloneuron indicum, Palaquium ellipticum, Hopea wightiana* and others. (iii) *Valleys of the Bhadra river source in South Bhadra State Forest – Poeciloneuron indicum*, almost pure in places (K. Kadambi, 1942).

(3) *Palghat division, Madras*—(i) *Poeciloneuron – Palaquium* association*: Poeciloneuron indicum, Palaquium ellipticum, Calophyllum elatum, Mesua ferrea, Cullenia excelsa, Vateria macrocarpa* (optimum moisture climatic climax – T. V. Venkateswara Ayyar). (ii) *Reed – Poeciloneuron : Poeciloneuron indicum, Hopea glabra, Eugenia* sp., *Bischofia javanica* and *Ochlandra* (wet soil climax with the above association – T. V. Venkateswara Ayyar).

(4) *Lower Kalar valley shola – Coimbatore South division*—*Poeciloneuron – Cullenia* association, with an almost pure crop of *Poeciloneuron* with a small admixture of *Cullenia excelsa*. The association is probably due to edaphic factors, and is found in places where the soil has a high moisture content for the greater part of the year. (T. V. Venkateswara Ayyar).

(5) *Shenkottah, Travancore-Cochin*—Here the associate species of *Poeciloneuron indicum* include *Dipterocarpus indicus, Dichopsis ellipticum, Mesua ferrea, Calophyllum tomentosum, Canarium strictum, Kingiodendron pinnatum, Gluta travancorica* and many others (M. N. Menon).

Leaf shedding, flowering and fruiting—The tree is typically evergreen, but owing to the great variations of moisture conditions between the rainy and dry seasons the density of leaf cover in the canopy varies appreciably and the onset of the dry season is accompanied by heavy leaf shedding which reaches its climax in February–March ; the tree crowns are, therefore, lightest at the height of the dry season.

The flowers appear in December and last till March. At the height of the flowering season in the latter part of January and the first half of February, the flowering is so copious that the tree crowns appear cream coloured from a distance and the air in the forest is often filled with their sweet scent. The fruit ripens from June to August, the height of the fruiting season being July. Every alternate year is a good seed year.

Each fruit has a single, erect, exalbuminous seed. In nature germination starts in August. The growth of the seedling is at first rapid owing to the large amount of food-material stored in the fleshy cotyledons. The radicle, which is minute in the seed, develops rapidly a tap root six inches or more long, and the young seedling reaches under favourable conditions a height of six to nine inches within about a fortnight. Later on the growth is slow, and it practically ceases in the accompanying dry season. New season's growth commences after the first pre-monsoon showers during next April.

Silvicultural characters—In its early stages the tree is shade tolerant but as it advances in age it demands more and more light until in the adult stage it is a strong light demander and is nearly killed if overtopped by other forest trees. The pointed crown, which the tree develops early in its life enables it to make its way persistently upwards through the dense mass of evergreen vegetation in which the tree finds itself, the length of the crown increasing greatly, compared to its width. The lower branches, which are shut off from light, die early, leaving behind dead knots and branches which decay, get overgrown by sound, woody tissue and often cause characteristic defects in the timber. Once the tree has reached the top storey of the evergreen forest, the crown begins to expand more or less laterally, the thin, long, bole puts on girth rapidly and the tree assumes its adult stature in a short time. Pronounced anatomical differences are found between the leaves found in the shade of the evergreen forest and those which are found in the adult trees whose crowns are exposed directly to sun ; the latter have a thick cuticle and sunken stomata, an adaptation required for reducing transpiration. (*Ind. For.*, April, 1942, p. 220).

The tree loves abundant moisture but dislikes poor drainage. In the Bhadra river source valley of Chikamagalur district, Mysore State, the tree, which here is of the black variety, frequently grows in the beds of streams with a portion of its root system periodically submerged in running water (Fig. 4). The 'black' variety of the tree is less sensitive to water logging than the 'white' one.

Seedlings of *Poeciloneuron indicum* are sensitive to drought and large numbers of seedlings which spring up after each good seed year but found in exposed situations perish in the ensuing hot season.

Like most evergreen forest trees, *Poeciloneuron* is sensitive to fire, and except when the injury from this source is confined to superficial scorching of the bark, the tree is killed outright by it. There is, however, little chance of the tree being exposed to severe fire in the evergreen forest. The tree coppices very well.

The way in which *Poeciloneuron indicum* has adapted itself to the growth conditions in evergreen forests has been studied in some detail (Kadambi, 1938). Its acuminately tipped foliage permits of the rapid draining off of water from the leaf surface, so that the photosynthetic activity may proceed unimpeded by preventing the formation of a film of water covering the leaf surface during the season of incessant rainfall. The stilt-shaped roots are

adapted to give stability to the tree on the very steep slopes (gradients of 70° and more) on which the tree sometimes grows on the Western Ghats, where the surface soil gets washed out as a result of the heavy rainfall. The leaf of seedlings and saplings, which have to thrive in the dense shade of the evergreen forest is shade bearing in character, with a poorly developed cuticle, a single layer of palisade tissue and well developed spongy mesophyll.

Reproduction, natural and artificial—The tree reproduces itself freely in nature, and especially in felled areas seedling regeneration and advance growth are often copious. In virgin forest also its natural reproduction is adequate. The most essential condition for the successful germination of its seed and establishment of the seedling is the availability of mineral soil, i.e., soil free from the dense carpet of fallen decomposing organic matter so that the radicle can anchor itself as soon as it emerges out of the germinating seed. Another, though less important factor is light, which ushers in with it the warmth required for the rapid germination of the seed. These two conditions are best satisfied on elephant drag paths and other interior extraction paths, or in places where the mineral soil has been laid bare on account of the fellings and other operations. In good seed years such places are often covered with a dense carpet of seedlings.

The thick layer of fallen, dead leaves found on the floor of the evergreen forest is one of the chief causes which impedes the establishment of the young seedlings soon after the seed germinates. The presence of the two thick cotyledons with adequate nourishment enables the embryo to develop a long tap-root which seeks to establish contact with the minearal soil. The earlier this contact is made after germination the better does the root system of the seedling get anchored in the mineral soil, and the stronger it becomes to overcome the drought of the ensuing dry season which often accounts for the death of a large proportion of these seedlings.

Another factor which accounts for the annual loss of natural seedlings is weed growth. Whenever a break in the evergreen canopy occurs, a mass of rapid growing annuals and perennial weeds, which are usually the pioneers in the succession of vegetation in every evergreen forest, come up and eliminate large numbers of seedlings of the tree species. Among such weeds are: the wild cardamom, the wild turmeric, *Leea sambucina*, *Callicarpa lanata*, *Colebrookia oppositifolia* and several others.

The large seeds weigh one oz. or sometimes more each, 12 seeds weighing a pound. Germinative capacity recorded is low, only about 3 out of 24 selected seeds having germinated in Dehra Dun but the seeds put down for germination are stated to have got mouldy. The average of a number of seed tests made at Agumbe, Mysore State, during 1934 gave a germination of 56 per cent for fresh unselected seed, and this figures probably represents its correct germinative capacity. The large mass of natural seedlings which are encountered during each good seed year indicates a fairly high germinative capacity for the seed.

The tree can be raised successfully by transplanting and 90 per cent survival has been obtained by this method in Madras State. It has not, however, been stated how old the seedlings were at the time of transplanting; in view of the long, fibrous tap root which the seedling develops, it is unlikely that entire transplanting can be done with success with seedlings over 1 season old. Direct sowing has not been tried (Silv. Res. Rpt., Madras, 1939–40). Notching germinating seeds would probably be found most appropriate for regenerating this species. In Mysore State this method has been tried with success. The species cannot be stump-planted.

Methods of management—In Mysore State the tree has been exploited since the year 1920 for preparing electric transmission poles. The forests are worked on a selection *cum* thinning principle; trees of the girths required for making these transmission poles, generally 2½ to 4 feet in girth, are extracted from localities where the natural crop is in need of a thinning. In areas where the forest has already been exploited for poles and *Dipterocarpus* sleepers it is

subjected to tending operations aiming at the advancement of the copious regeneration which invariably come up as a result of the fellings. The tending operations are prescribed to be done in 3 stages, each on a 20-year cycle as follows :—

(A) *Initial stage*—In this stage all undergrowth of the forest except the regeneration of the *élite* tree species among which *Poeciloneuron* is one, are cut away; climbers and other unwanted growth are removed.

(B) *Intermediate stage*—In this stage periodic removal of the middle layers of the forest canopy, of saplings and poles of unwanted species and miscellaneous undergrowth are done.

(C) *Final stage*—In this stage all overwood stems of the *élite* species, of and above the exploitable size are removed, this being 5 feet for *Poeciloneuron*.

Rate of growth—Under favourable conditions the rate of height growth of the tree in the early stages is moderately fast. The following rate has been recorded in natural forest :—

1st year – 9 inches ; 2nd year – 2 feet ; 3rd year – 3½ feet ; 4th year – 6 feet ; 5th year – 7 feet. One of the most important factors affecting the height growth of the tree in nature is the influx of overhead sunlight. In the absence of such light height growth stagnates as the following figures will show :—

Poeciloneuron indicum—Height measurements of natural seedlings and saplings growing in dense shade, Agumbe State Forest, Shimoga division, Mysore State.

Date of Measurement

28–5–38		13–8–38		28–11–38		27–4–39		May 1940		May 1941	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
8	8	8	9	8	11	9	3	9	5	10	0
7	7	7	7	7	8	7	8	7	9	8	0
11	11	12	2	12	2	12	2	12	3	12	6
12	0	12	0½	12	0½	12	6	12	7	12	9
4	4	4	5¾	4	8	5	5½	5	7	6	0
18	2	18	4	18	5	19	0	19	3	19	5
9	4	9	8	9	8½	9	10	10	0	10	3
12	9	13	1½	13	1½	13	2	13	3	13	6
2	9	2	9	2	9	3	1	3	3	3	5
22	0	22	2	22	3	22	4	22	7	22	10
17	2	17	4	17	4	17	8	17	10	18	2
2	8	2	9½	2	10	3	0	3	7	4	0
15	4	15	5	15	6	15	6	16	0	17	0
8	0	8	1	8	2	8	2	8	3	9	0
5	5	5	6	5	8	5	11	6	0	6	3
4	3	4	4	4	5	4	5	4	6	4	8
13	0	13	2	13	2	13	6	13	7	13	9
2	1	2	2	2	2½	2	3	2	6	2	9
5	1	5	1	5	1	5	1	5	2	6	0
7	9	7	9	7	9	8	2	8	3	9	0

The following girth increment data have been calculated from the existing increment plot of Agumbe Range, Shimoga Division, Mysore State :—

Poeciloneuron indicum – rate of girth increment

Girth of tree feet	C.A.I. in girth inches
under 1½ feet	0·25
1½ to 3 feet	0·38
3 to 4½ feet	0·68

(W.P. for the Ghat forests Agumbe, Balehalli, Verahi, Manilyle, Hulikal and Kilandur, of Shimoga and Sagar Divisions, 1941–61, p. 101).

Utilization—Poeciloneuron indicum is one of the most important woods of the Ghat forests which, by virtue of its durability and its capacity to develop clean, straight, cylindrical boles of considerable lengths, has been used for about 30 years almost exclusively in lieu of steel poles on the high power transmission lines in Mysore State.

Moderate supplies are available, the annual yield from the forests of Shimoga and Chikamagalur districts in Mysore State alone being estimated at 3,000 tons. The yield from other areas is not known.

General characteristics of the wood—The wood is dark red with a darker heartwood, rather dull, with smooth feel, without characteristic odour or taste, almost straight grained and medium coarse textured. Occasionally trees with interlocked fibre and very coarse grain are found. Weight per cu. ft. at 12 per cent moisture content is 55 lbs. (Pearson and Brown), 71 lbs. (Limaye). Kann, who has tested the wood in the Indian Institute of Science, Bangalore found the weight per cu. ft. of air-dry wood to be 66 lbs. but the wood of the 'black' variety of this tree was found to weigh 69½ lbs. per cu. ft. (Kadambi, 1938, p. 216). The strength of the wood from North Mangalore, Madras as compared to teak is given in the following table (V. D. Limaye).

Poeciloneuron indicum—Suitability expressed as percentages compared to Burma teak.

Weight	Strength as beam	Stiffness as beam	Suitability as post	Shock resisting ability	Rentention of shape	Shear	Hardness
165	140	150	145	145	45	180	265

The timber is not difficult to season, though if left in the log is liable to develop a star shake. It is difficult to saw and works fairly well by hand and on machines. It is durable in open situations. It can be antiseptically treated with ascu and creosote.

Uses—Its most important use in Mysore State is for electric transmission poles. The wood is also used for building purposes and for rice pounders in parts of Mysore, Malabar and Travancore-Cochin. Troup says that railway sleepers made of the wood have given satisfactory results on the Madras Railways where sleepers laid down in 1899 stood fairly well up to 1907. Half-moon shaped sleepers prepared at Bhadravati, Mysore State, laid on the tramlines have also done very well. The wood is stated to be suitable for paving blocks.

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LIST OF ILLUSTRATIONS

FIG. 1.—Two trees of *Poeciloneuron indicum*, Bedd. The one in the background is about 112 feet high. That in front shows the clean, straight bole which this species is able to develop. Agumbe State Forest, Shimoga Division, Mysore State.

Photo—Author, April, 1938.

FIG. 2.—Lower portion of the bole of an adult *Poeciloneuron* tree showing its cylindrical bole poised typically on stilt roots. The tree on the right is also *Poeciloneuron*. Agumbe State Forest, Shimoga Division, Mysore State.

Photo—Author, March, 1938.

FIG. 3.—*Poeciloneuron indicum* (black variety) showing how the tree is gregarious. Bhadra river Source valley, South Bhadra State Forest, Chikmagalur district, Mysore State.

Photo—Author, 1942.

FIG. 4.—A pure patch of *Poeciloneuron indicum* (black variety) growing in the rocky bed of a hill-stream, Bhadra river Source valley, South Bhadra State forest, Chikamagalur district, Mysore State. Observe how the buttresses often run up to considerable heights on the stem.

Photo—Author, 1942.

FIG. 5.—A typical view of the buttresses in an old tree (white variety) illustrating how the stilts – (see Fig. 2) are getting flattened out into buttresses. Agumbe State Forest, Shimoga Division, Mysore State.

Photo—Author, April, 1938.

FIG. 6.—Distribution of *Poeciloneuron indicum*, Bedd.

TEAK THE INTRUDER

vis-à-vis

OCCURRENCE OF TEAK IN SAL FORESTS OF BASTAR

BY S. D. N. TIWARI

Working Plan Officer, North Bastar Division

SUMMARY

In the territory of old Bastar state teak and sal forests are found in two separate zones. Apart from the merging zone, teak is found scattered and in patches in the heart of the sal zone. In this short article the author tries to establish that this teak has been introduced by man specially on account of Royal patronage the Ruler having come from the teak area of the South. Profuse regeneration of teak in all such scattered patches is seen and sal is being replaced at many places so much so that one may be misled to believe it to be natural. Many deductions have been drawn from this study – some of the important ones being that sal had wider distribution in the past and its territory is being curtailed at many places; secondly in evolution sal which belongs to a much older family than teak will gradually be replaced by teak and thirdly, teak plantations in the sal zone should normally be successful specially in those areas where ecological factors are favourable.

The total area of the old Bastar state is about 13,000 square miles the forests of which are now managed under the North and South Bastar Divisions. Topographically the area is characterised by great north-eastern plateau of Jagdalpur about 100 miles long and 60 miles broad, with an elevation of about 2,500 feet in the north to about 1,800 feet in the south; the hilly area of the Abhujmar is in the mid-west and the plains area in the south and the north-west with a few hills. Sal forest is found on the great plateau, its foot-hills and in Abhujmar but, it has disappeared from the plains and teak is found in its place. Of course, in both the cases in unsuitable areas stretches of miscellaneous forests are found. In short, the two large zones of teak and sal are quite distinct.

Occasionally, in the sal forest a few teak trees are found, the size of which may vary from saplings to trees of over 5 feet girth. Natural regeneration round about these trees is quite common. In the Kondagaon range which is more or less in the middle of the plateau and miles away from the teak zone its occurrence is rather rare while towards the outside it is more common. Since my arrival to this division about 2 years ago I have been trying to solve this puzzle as to how these trees have happened to intrude into the domain of sal and only recently after wandering through many such areas I have been able to put forth some sort of explanation.

When I was touring Kondagaon range a few teak trees were noticed along the Narangi river near Bhumka nalla, later on near Bamni and so on. On enquiry from the local staff, it was gathered that the teak seed perhaps came by water from up the stream. In the second field season I had to tour the area nearly up to the source of the river but the sal zone still continued though at a few places similar scattered teak trees were found. Thus the explanation was apparently not satisfying. Later on, one or two trees were found near Karyakanta in North Golawand block which are about 5 feet in girth. A very large number of trees were seen along the Bhawardig river near Malnar and their girth is mostly over 5 feet. A small patch of teak was found near Binjoli inside the reserved forest in Makri range. In the North Kanger area teak is found to a very large extent and at many places sal and teak grow in

equal proportions. In Narainpur range the percentage of teak has increased to very great extent and nearly along all old roads, forest blanks, hill-sides, etc., teak is found. Thus the riddle became more puzzling. During my discussions with other local forest officers, some attributed the occurrence of teak to change in the rock and soil. Obviously, the solution does not lie in this because there comes the question of the coming in of seed to that locality from a distance of several miles and that too after carefully avoiding intermediate sal zone which has a more or less similar geology and soil. I had my own doubts that the teak must have been introduced artificially but there was no record or verbal evidence about this, nor would anybody agree with me. The puzzling factor was the occurrence of natural seedlings found scattered at many places especially along water courses.

The first evidence of the artificial introduction of teak came from Shri Dhaniram (he is popularly known as Dhania) of Nilgi village who is about 74 years old. When I was camping near Tareka a large number of teak trees were noticed in that blank and anybody could say that they were there only by planting. Tareka used to be a big village about 40 years ago, so stated Dhania, before the forest was reserved. At the time of reservation in 1908–10, which was done rather too suddenly, the aboriginals left the village when they were asked to cut the demarcation lines of the Reserve, perhaps out of sheer panic. Nearly all the villages within the reserve were thus, abandoned at that time and this is how reserves of over 300 square miles area without any villages inside them were formed. Actually, the few forest villages which are found at present were habilitated in recent years.

Due to this mass-scale desertion big blanks were formed. It was about 6 years later that the forest department had got these blanks sown with seed in the hope of restocking them. The seeds were dibbled in scattered patches. They were hardly looked after later on. However, this sowing was continued for the next 2 or 3 years and quite a large number of seedlings were thus obtained. Two big trees about 60 feet in height which were 48 and 50 inches in girth were got felled and ring counting was done. One of them showed 33 and the other 34 rings. Allowing about 2 years for their establishment or for the seedlings to struggle against fire and other adverse factors the year of their inception will be about 1917 ; thus the statement of Dhania is more or less correct. He also said that the solid patch of teak along the Narangi river near Baniagaon was planted by him. The above growth is rather too fast and it would be difficult to believe the story specially because the trees are growing on very poor soil, but for the evidence from ring counts. It is very likely that those seeds which were washed away and had got a better soil and moisture along the banks of streams have grown to much bigger sizes. The number of trees is now increasing very fast as teak is regenerating itself successfully. Its seedlings have been found to come up in blanks, under heavy shade, along streams and also in rocky areas. A few streams flow through the Tareka blank and the source of many seedlings found downstream can be traced to that place. During the high floods in the Indrawati most of the streams are blocked with back-water and the water spreads to a distance of many miles. All this teak cannot be called as growing in its natural habitat but is a true intruder.

On account of dense forests and long distances from any civilized area the Bastar State remained uninfluenced by the outsiders till very recently. The aboriginals form the major portion of the population. They hardly stuck to any village. Along with the shifting cultivation the village sites also shifted and most of the villages shown on the old Survey of India sheets are hardly found in their position. Thus, at the time of reservation apart from the village sites abandoned at that time there must bave been many more blanks due to abandoning and shifting of villages in the past. They must have also been dibbled with teak seed in a similar fashion. In Narainpur Range teak trees are found inside the reserve on very steep hill slopes and even on the low hill-tops. One such patch is found on Bepari Dongri

near Palki. At first sight it is difficult to believe that these slopes were once under shifting cultivation, but a visit to the adjoining Abhujmar area will dispel all such doubts. There, shifting cultivation fields may be seen on any steep gradient.

The collection of teak seed and its transport from long distances must have limited the scale of planting in areas very remote from the teak zone, and this accounts for the rare occurrence of teak in Kondagaon range and its wide spread occurrence on the fringe of the plateau in the Kanger valley and Narainpur range.

Unfortunately it is difficult to get men like Dhania who had done all this sowing of teak seed in remote places. I could get evidence about it in the case of teak at Takrel in Narainpur Range and also few planted trees were shown to me in Kolur. But, for the rest of the area it is all idle speculation. The life of the aboriginals is on an average much shorter than ours, or perhaps the villagers who went to plant up their own fields were cursed by their gods or killed by their own brethren. A few of those who are still alive hesitate to speak of their own work.

Moreover, an aged man in a village is much respected, and he hardly comes to the camps of officers. If, however, one insists upon meeting him he becomes suspicious of such enquiries. In their earlier years the aboriginals suffered much exploitation and perhaps nobody among them wants to be reminded of the hard days. Actually, the loss of such evidence on a large scale and the non-availability of any old office records has made the getting of evidence difficult. A very large scale stump analysis of this scattered teak trees should probably yield valuable information.

However, all the teak cannot be attributed to this seed dispersal after the reservation of forests because very old trees over 6 to 7 feet in girth, are seen in many places. Dhania himself told me that a few big trees growing near Binjoli village in the Makdi Range were quite big when he was a boy. That the introduction of teak had started much earlier than Dhania's time can be made out from other evidence. In Kodoli – a small Madia village in Matla block a few dozen of teak trees were found growing inside cultivated fields of the villagers. The village was deserted at the time of reservation and has been rehabilitated only about 10 to 12 years ago. One of the trees which is over 75 feet in height and 6 feet in girth presented a problem because it could hardly be believed to have grown from the 1917 sowings. The village head-man is a middle-aged man, and he could hardly give any clue about the cause of its existence. However, his father who had recently returned from Jagdalpur jail after commutation of life sentence for murdering his own brother, is alive. He did not come to the camp when sent for ; and finally I went to him and met him in his field. At first, he was quite hostile and reluctant to answer me, but later on he became very free and friendly. He told me that when he had deserted the village the tree was about 25 feet in height and 2 feet in girth and that he had seen the tree since his infancy. All other trees of smaller sizes growing around about it came up from the seeds of that tree and no one had planted them. Thus it is clear that teak was planted much before the reservation of the forest. I have been able to collect a few names of the officers who were fond of planting teak.

It was in 1897 that the forest department was started in the State and Mr. Hunt was the first officer to be appointed. He was previously in charge of Allapalli range famous for its teak in the Madhya Pradesh and there is oral evidence that he had initiated some sowings. He was followed by Mr. Rooke, again a forest ranger from Madhya Pradesh who also did some teak sowings. At what places they did these sowings is not known but I was lucky in meeting some of the old people who were serving at that time and they all confirmed that both the officers did teak sowings at many places.

Bastar had very profitable trade in teak from 1850 onwards which was mostly managed by Lal Kalindra Singh, Dewan and cousin of the then Maharaja Bhairam Deo. He used to pay the royalty to the Maharaja and managed the business for himself. All the timber was floated to Rajmahendry by the river. Thus it is very likely that special interest might have been taken at this time to introduce teak into sal forests which were then quite worthless, in order to make the State's forests more valuable.

Teak is a royal tree in Bastar State since times immemorial, and it is very likely that efforts to plant teak were made a long ago.

It will be easy to understand this desire for planting teak if I mention something about the history of the Ruler's dynasty from Grigson's book (the Maria Gonds of Bastar). The present ruling family belongs to one of the most ancient families of South India, the Kakatiya, which reigned at Warangal from about A.D. 1150 to 1425, at first possibly as feudatories of the Chalukya Kings and later on independently. Pratap-Rudra, the greatest and the last independent Kakatiya King of Warangal lost his life and independence in a battle with the Mohammedan invaders of the Deccan under Ahmed Shah Bahmani, early in the fifteenth century, and his brother Annam Deo fled across the Godavari into Bastar, which had been one of the outlying and loosely held group of feudal dependencies of Warangal, because inscriptions show that before this, in the eleventh century, the Telegu line of Nagwasi Kings ruled at Barsur in Dantewara Tahsil (South Bastar) and at Kurcepal near the Chitrakot falls of the Indrawati. Before Annam Deo's arrival there, there was a nominal suzerainty of Warangal over most of Bastar, the real authority resting with local chiefs or in the heads of the old tribal organization. Thus it is clear that the present ruling dynasty came from South and even the earlier Nagwasi dynasty was from the South. There is every likelihood that the planting of teak was given an impetus from the very beginning of their arrival and it is from that time onwards that teak was declared as royal tree in Bastar. No rayat is allowed to fell it wherever found, without the state's permission. It had thus the Royal patronage. In those early days sal had hardly any value specially as it could not be floated down rivers and carried to the markets. Teak being an all-round timber it had a market since times immemorial, and it is quite likely that the rulers had made some efforts to introduce teak in the State. The village head-men were more successful in introducing it in the teak bordering areas on account of the easy availability of seed while the question hardly arose about introducing it in the very interior areas because of want of the means of communication. Perhaps the planting of teak was not popular but it was just a Royal desire. This fact combined with the fact that village sites in Bastar continuously shift, gives strong evidence in favour the assumption that teak was introduced by man even in places where big teak trees are found growing together in dense forests. It is also possible that the present southern boundary of the sal zone has considerably receded owing to the superiority of teak over sal in resisting adverse factors like fire and shifting cultivation specially as it had royal protection. Even now, the best teak forest in South Bastar Division is found in village holdings. Similar is the case with the southern sal ranges of North Bastar Division. Even in Narainpur Range wherever large and wide-spread teak is found old village sites may be discovered in the vicinity. In many cases these deserted village sites have been shown on the 1876 Survey of India maps while in some cases the local name is keeping the history alive (as explained under "Muria Nomenclature", *Indian Forester*, Oct., 1953). Wide occurrence of teak in village holdings is very common in most of the Chhattisgarh States (like Kanker) and what has been seen in Bastar in different stages of evolution may throw much greater light on the ecological status and types of those forests.

Wherever teak trees have been noticed, its profuse regeneration is found to accompany it and this shows that the soil is favourable to teak all over this area. In Kurschel valley

where some of the teak trees are over 12 feet in girth and up to 126 feet in height (see photo No. 1) sal is not seen anywhere else except in a small shelf in a protected gorge of Matla nalla where 8 to 9 sal trees over 7 feet in girth are found. It appears that in course of time teak has replaced sal in all favourable situations. Near Hurtalai an earlier stage of this invasion is seen where teak and sal are found nearly in equal numbers at many places (see Photo No. 2). Thus in nature too it is seen that teak can easily oust sal from the latter's natural habitat. The above observations amply indicate that if regular teak plantations are formed in the sal zone these should normally be successful. Actually, in Bastar, wherever, such plantations have been formed they are successful. Recently Shri J. N. Sinha and A. Haidery of Bihar have stated (*Indian Forester*, Feb., 1953) that in Bihar, teak plantations have succeeded very well in the sal zone. In Kanha, in Mandla division, teak is seen spreading on a small hillock in front of the Rest-House from a few trees planted sometime ago in a pure sal forest. Sal belongs to an old family or *Dipterocarpaceae* while teak belongs to one of the most advanced familes of *Verbenaceae*. Thus Botanically also it appears that this intrusion of teak on sal territory is not a recent phenomenon but is happening from a long time. Perhaps sal had much wider distribution before than at present and teak has already snatched some of its territory. If this is so, there is hardly any chance for sal to survive as the evolution proceeds. At the beginning teak was proceeding ahead only at their meeting zones, but with these sowings and plantations in the heart of sal forests the process is bound to be faster. Actually if teak could anyhow disperse its seeds in the sal zone at a much faster rate (or if helped by man), the clash between the two for the supremacy over the ground should come to an end much earlier – of course teak coming out as a winner.

PHOTO No. 1
Teak in Kurschel Valley where Sal has been completely ousted. The tree in the middle of the picture, measures 12′ 6″ girth, 126′ height.

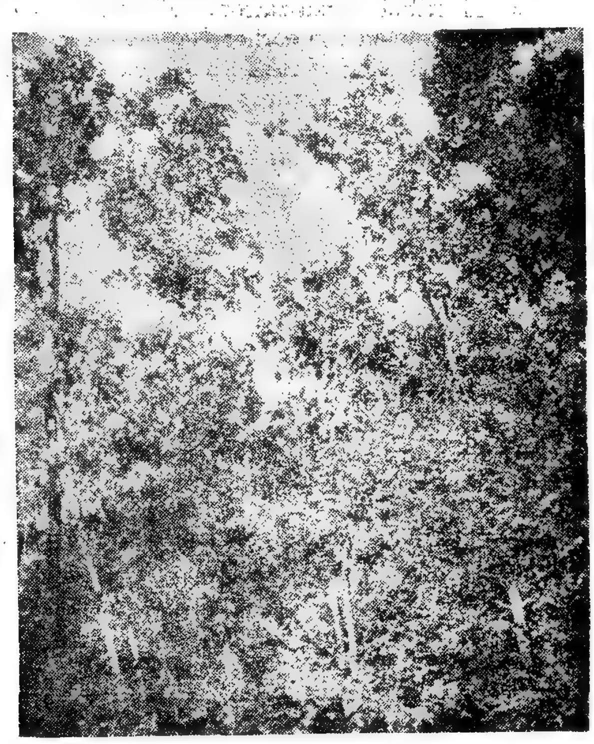

PHOTO No. 2
Sal and teak in equal proportion in Hurtalai Narainpur Range.

Teak has been able to make so much headway in Bastar without any plan or any organized drive to grow it. What will happen after fifty years or so of well-planned management can easily be visualized now. In most of the ranges teak plantations have already been started. On account of the long lead to railhead it is hardly worthwhile exploiting sal below 3 feet in girth, and returns from sal forests are definitely much lower than from teak forests. Thus teak, the intruder, is bound to become a successful invader in course of time, may be 50 years or more hence with the support of so many favourable factors combined with human interference. Miscellaneous forests, with even little teak have hardly any hope of survival. In sal forests it is quite likely that with wiser management teak may continue in mixture with sal for some time, and the sal in central portions of the plateau may remain pure for a few centuries but sooner or later (if the present climatic and edaphic conditions last) teak is bound to replace sal. The Kakatiyas came to Bastar from south, ruled and are now no more the rulers, but the co-invader who accompanied them (teak) will prove much stronger than them, and will make the history of their times immemorable for all times to come.

SHORT NOTE ON INDIAN BALSA

BY D. NARAYANAMURTI AND N. C. JAIN

Balsa (*Ochroma* sp.) a native of the West Indies and tropical America attained importance on account of its lightness and insulating properties. During the last war it was used as a sandwich material in the Mosquito fuselage, etc. It is a quick growing tree reaching 30 to 70 feet in height and a diameter of 24 to 30 inches in 5 years. The density of the wood at 15% moisture content can vary between 5 to 10 lbs./c. ft. Individual samples may weigh anything between 2·5 to 25 lbs./c. ft. It is stated that timber from natural growth balsa is heavier than that from plantation grown timber. Till recently India was entirely dependent on South America or Java for supplies of balsa. Recently the Madras and Mysore Forest Departments have introduced the species in this country. It was, therefore, thought of interest to study timber from Madras.

Material used for the investigation—Logs from 3 trees were obtained from Madras*. Fig. 1† shows a balsa tree 3 years old in Mount Stuart. The logs received had a girth of about 45 inches. They were sawn into planks, kiln dried and the properties studied.

Properties studied—The properties studied included: Drying characteristics, density, strength properties, gluing characteristics, thermal conductivity and chemical composition.

RESULTS AND DISCUSSION

General—The material was a little blue stained and there were a few knots. Otherwise it was of satisfactory quality.

Density—The density of the material on the average varied from 0·16 gm/cm.^{3} to 0·28 gm/cm.^{3} (10 lbs. to 17·5 lbs./c. ft.). Individual samples tested varied in density from 0·098 gm/cm.^{3} to 0·305 gm/cm.^{3}, the average being 0·198 gm/cm.^{3}. According to Kollmann the density can vary from 0·07 gm/cm^3. to 0·44 gm/cm.^{3} the average being 0·16 gm/cm^3. The balsa tested by Wiepking and Doyle had an average density of 0·13 with a range from 0·06 to 0·24 gm/cm.^{3}. Raymond Ponderoux reports an average density of 0·125 gm/cm^3.

Drying characteristics—Tests were kindly carried out by the Seasoning Branch who reported as follows:

> "The timber was kiln seasoned in 12 hours from a maximum of 76% moisture content to 10% moisture content in an internal fan kiln. The timber did not develop any defects. Only the heart shake slightly opened out and there was splitting around a few knots. Balsa is a very quick drying timber".

Elasticity and strength properties—The modulus of elasticity in bending and damping in flexure were investigated by vibrational methods (*vide* Narayanamurti and Jain 1951). The modulus of elasticity in bending of the specimens studied varied from about 25×10^9 dynes/cm.^{2} ($362·15 \times 10^3$ lbs./sq. in.) to 36×10^9 dynes/cm.^{2} (522×10^3 lbs./sq. in.), the average being 31×10^9 dynes/cm.^{2} ($449·5 \times 10^3$ lbs./sq. in.). This is lower than the values reported by Wiepking and Doyle but higher than the values given by Kollmann and corresponds to the value for balsa heartwood given by the Royal Aircraft Establishment.

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* Kindly supplied by the Silviculturist, Madras.

† Photo kindly supplied by Shri M. S. Raghavan, formerly Central Silviculturist.

The damping capacity in flexure along the grain for specimens of about 8·5% moisture content varied between 0·0160 and 0·031%. The reason for this wide variation is not known and is being investigated.

FIG. 1

Results of tests on other strength properties are given in Table I below. As can be seen the results compare very favourably with those of foreign observers.

TABLE I

Species	Density gm./cm.^{3}	Tensile strength lb./sq. in.	Modulus of rupture lb./sq. in.	Compressive strength lb./sq. in.	Shear strength lb./sq. in.
			Authors Results		
Ochroma sp. ..	R1 0·20 (8·93)	2900 (8·93)	4868 (8·93)	2368 (10·8)	976 (6·6)
	R3 0·16 (8·67)	2310 (8·67)	4603 (8·67)	2748 (11·4)	678 (6·6)
	R7 0·18 (6·42)	2783 (6·42)	3508 (6·42)	2068 (11·7)	690 (7·2)
	R8 0·16 (8·86)	2030 (8·86)	4003 (8·86)	1909 (6·7)	838 (4·0)
	T1 0·26 (9·21)	5107 (9·21)	4445 (9·21)	2972 (10·8)	829 (7·2)
	T8 0·28 (9·93)	6213 (9·93)	5833 (9·93)	3180 (6·7)	1013 (8·6)
	T11 0·28 (10·34)	6517 (10·34)	4803 (10·34)	2765 (8·1)	774 (11·7)
	T12 0·21 (10·23)	3114 (10·23)	4365 (10·23)	3163 (8·6)	753 (10·1)
Ochroma sp. ..	Heart ..	..	2800 (12)	1680 (12)	.. R.A.E.
Do. ..	Sap. ..	..	5300 (12)	3730 (12)	.. do.
Do. ..	..0·07–0·16–0·44	..	640–2280–4700	427–1140–3280	.. Kollmann
Do. ..	.. 0·125	..	2840	1140	.. Ponderoux
Do. ..	.. 0·16 0·18 0·20	.. .. ..	2875 3350 3750	1850 2150 2450	350 Wiepking 385 and 440 Doyle
Bombax malabaricum	0·333	..	6130	3500	570 780 Limaye (R & T)
Cryptomeria japonica	0·236	..	3425	2030	630 675 „ (R & T)

The figures in brackets represent the moisture content. R means radial and T tangential.

Thermal conductivity—The thermal conductivity of a specimen of density 0·24 gm./cm.^{3} at 12·2% moisture content was found to be 0·0796 Kcal/mh°C. in the radial direction.

Gluing properties and sandwich constructions—The gluing properties of the material were investigated in lap joint tests with animal glue, casein glue, urea-formaldehyde glue, resorcional-formaldehyde resin glue, cashew nut shell liquid adhesive and Pliobond. In all cases the joints when tested failed in the wood. Some sandwich boards with balsa core and thin resin bonded plywood faces were made and tested. As the adhesion of the resin impregnated plywood was not very good these tests are being repeated with Tego bonded plywood faces.

Chemical examination—A specimen from near the heartwood was analysed with the following results : Moisture 8·77%; ether extracts 1·35%, Alcohol-benzene extractives 1·79%, hot water extractives 2·37%, ash 3·49%, pentosans 21·99%, cellulose 55·54% and lignin 23·98%.

Uses of the material—The main uses of the material are : non-stressed parts of aircraft, railway carriages, walls, pontoons of sea planes, life saving devices, life boats, lifebelts, life buoys, surf riding floats substitute for cork stoppers, linoleum, orthopaedic splints, heat and cold insulation, acoustic correction, packing material, foundations of machines, toys, etc. In sandwich constructions it can not only find application in aircraft but also in flush doors, partitions, furniture, flooring, instrument cases, roofing, truck parts, etc.

The material so far examined is somewhat on the heavier side. The specimens are superior to *Cryptomeria japonica* tested by Limaye and compare well with *Bombax malabaricum* in strength. Further experiments on a sufficiently large number of trees are contemplated. Sandwich panels with Indian balsa will also be tested.

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A QUESTION OF PRIORITY IN A BURMESE *DILLENIA*

BY DR. C. X. FURTADO
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In a recent number of the *Indian Forester*, 79 (Oct. 1953) 524 + pl., under the title "A New Burmese *Dillenia*", M. B. Raizada and R. N. Chatterji make a surprising claim for priority for a manuscript name and notes written by the senior author on the herbarium sheets. The Nomenclatural Rules do not recognize the validity or priority of manuscript names and descriptions, a fact which seems to have been recognized in practice by the two authors, as will be seen presently. The case may be stated as follows :

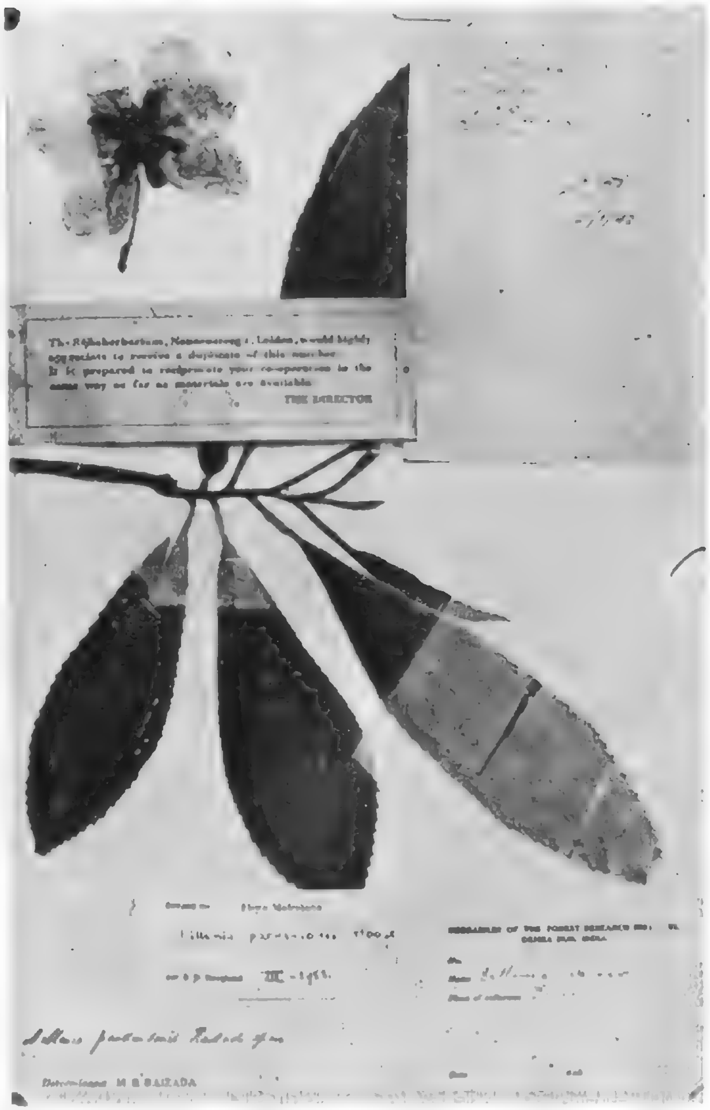
In 1949–50, R. D. Hoogland assembled in Leiden a large collection of Malaysian *Dilleniaceae* and published a revision in Flora Malesiana IV pt. 3 (1951). Non-Malaysian *Dillenia* are very few in comparison with the Malaysian species and since he had already had opportunities to examine a good deal of non-Malaysian material of the genus *Dillenia*, he proposed to make an extended revision of it. Hence in 1951 he applied for the material from many other institutions including that from the herbarium in Dehra Dun. In the collections of this institution Hoogland found a specimen collected in Burma in 1939 which was identical with another specimen he had named from the Kew Herbarium as *Dillenia parkinsonii* Hoogl. The Kew specimen, which was also collected in Burma and numbered 863, was made the holotype of the new species.

Now Raizada and Chatterji claim that Raizada had already appended that name to the sheet and given descriptive notes under it on the sheet lent to Hoogland and so the latter should have credited the name to Raizada, though as said above, this claim cannot be sustained under the Rules. On the other hand Hoogland states (*fide* Wyatt-Smith) that he had seen neither the name nor the notes on the sheet, a fact which makes one conclude that Hoogland had drawn up his description and named the Kew specimen long before he could get the Dehra Dun specimen, which he must have examined and included in the citations later. Further Raizada and Chatterji claim that the type of their manuscript name was not the specimen lent to Hoogland, and so one does not understand why the notes were appended on that sheet.

Further Raizada and Chatterji state that the species was not described before by Raizada because he lacked fruiting material ; and from their remarks and from the fact that even now they have not had fruiting material to complete their description, it appears that they published the name *Dillenia parkinsonii* in the *Indian Forester* because Hoogland had claimed to be the author of the species, a privilege which they wish to deny him, without investigating whether the name has been actually published by him or not. In fact they state that the specimen of the species was sent "inadvertently" to Hoogland, showing thereby that they did not wish that the proposed detailed revision of *Dillenia* of Hoogland should have been as complete as possible ; but it is clear that even if Hoogland has not seen the Dehra Dun specimen, the holotype from Kew was enough to establish the new species.

Now if Raizada should have been acknowledged the author of the species for naming and describing the species in the herbarium in 1942, why is then, when published in 1953 in the *Indian Forester*, Chatterji's name associated as the co-author of the species ? Obviously the authors are not consistent in their claims for priority in this regard.

Had Raizada and Chatterji made some inquiries about the work of Hoogland whose determinations they had found in the Dehra Dun herbarium, they would have found out


The Rijksherbarium, Nonnensteeg 1, Leiden, would highly appreciate to receive a duplicate of this number.
It is prepared to reciprocate your co-operation in the same way as far as materials are available.
THE DIRECTOR


TYPE

that *Dillenia parkinsonii* Hoogl. was published in the middle of January 1952 in Blumea VII, p. 115, Fig. 11, that is, more than 20 months before the issue of the name in the *Indian Forester*. Under the Rules therefore *D. parkinsonii* Hoogl. should be used as the correct name and *D. parkinsonii* Raizada and Chatterji relegated to synonymy, though based on a different holotype.

Note by Shri M. B. Raizada

Forest Research Institute, Dehra Dun

I am sincerely sorry to find that the penultimate para of our paper on *Dillenia parkinsonii* has been entirely misunderstood and the whole thing has been utterly misconstrued.

I admit I had not seen Blumea, wherein Hoogland's description of this species appeared, before describing the species. As a matter of fact, the article was written in good faith, in total ignorance of the fact that the species had already been described and published by Hoogland.

Now as it transpires that Hoogland's description of the species appeared in 1952 and ours in 1953, I have no hesitation in accepting priority of Hoogland's publication, according to International Rules.

It may be that Hoogland's description of the species is based on Kew specimen, but it will appear from the two photographs of our herbarium sheets (which were sent to Hoogland) reproduced here, that Hoogland had affixed determination slips, including in one case, a request for a duplicate, thereby leaving no doubt that he had seen the sheets, including the type sheet in July 1951. He must have also noted the fact that I had already indicated this species as new and named it as *D. parkinsonii* Raizada sp., nov.

Whatever the rules of nomenclature may be, it is conventional for the author publishing the description of a new species, to associate the name of the person who first detected the species as new.

The fact that Hoogland has adopted the same specific name as the one proposed by me on the sheet, which he had seen, is surely suggestive.

I LIVED IN THE MEM SAHEB'S BATHROOM

The Cobra tells his story

BY S. P. SAHI

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For many days, I do not remember exactly how many, I had lived in peace in the Mem Saheb's bathroom. But the fact that I took abode there while still a callow stripling and grew up to be a robust adult might help the readers to gauge the not trivial duration of my residence in that delectable environment.

I was born in the fuel godown by the servants' quarters of the Mem Saheb's bungalow. While still very young I learnt to prowl about in the big compound in search of food and sport.

There were a number of servants living in the outhouses and they had families consisting of garrulous women and children who fought among themselves and threw pebbles in the hedge.

I was mortally afraid of the humans yet strange to say I enjoyed a peculiar sense of security by living around their dwellings. Often I used to crawl in and around their premises in search of insects, frogs and the young of the mice upon which depended mainly my subsistence.

I held a queer notion about the humans. To me they appeared to be a race with set habits and actions. They seldom seemed to probe at things above or below their nasal height. This fantasy of mine perhaps made me somewhat too optimistic and saucy about my unilateral and clandestine associations with human habitations.

More often than not, during nights, particularly when it was all wet and raining, I used to scuttle into their houses and remain there unnoticed for days together. Dark dingy nooks and corners of their dwellings, poky gaps beneath the odds and ends of their belongings and smoke laden rafters of the ceilings were my favourite haunts. Whenever anybody happened to approach my way or fumbled at things around me I quietly slunk along the edges of the walls and remained unheeded. Man on the whole is a noble and unsuspecting creature.

In winter nights when it was cold and frosting I often liked to dose in the cosy warmth of their hearths. Once I nearly scalded my snout when I attempted to suck milk from a nearby bowl which was piping hot.

A dreadful incident occurred one day and that gave me my first taste of the blatant human hostility and prejudice against my tribe. One morning, after my nocturnal prowls when I was returning to my abode in the fuel godown, I was much disconcerted to find that the servants had engaged themselves on some fiendish task. They tossed the billets one by one out of the godown and flourished long brooms against the walls and the floor removing the frail cobwebs that glittered with the streaks of yellow sunshine and the pile of cosy soot on which I used to rest. As I sauntered unwarily towards the door one of the servants flung a piece of log at me which fortunately for me missed its mark. With superb dexterity with which our tribe is endowed by nature, I retrieved from the danger and ran head over heel for my life. A sonorous chorus of "Snake" "Snake" boomed out in the air and the servants rushed forth hurling at me a rain of billets, brooms and brickbats.

Dazed by the stupenduous din and commotion that accompanied the assault on me, I headed for the dense growth of weeds by the main bungalow. I was so unnerved that I had not the least hope of my escape from the gruelling peril that shadowed me. But once inside the weeds I was out of sight of my assailants except for the shuffling trail that I left behind among the lush green growth.

Suddenly as luck would have it, I found myself at the drain opening in the wall and I missed no time to escape into it. At the other end I found myself in a neat little room with glossy floor of black and white and quaint opalescent fittings which gleamed in the mellow light.

Hardly had I the time to breathe when suddenly a couple of servants probably the most plucky of the lot burst into the room brandishing massive sticks and unsparingly vituperative in their dialect. But by now I had safely launched myself beneath the grotesque pipe attached to the underside of a large vessel which I later on discovered was the Mem Saheb's bath.

The bumptious servants struck the floor, shifted the furniture in disorder, banged the doors and windows and rattled their sticks under the big bath in an attempt to outmanoeuvre me. But I shrank back and remained clinging to my place of vantage.

After much stamping, beating and shooing the servants left the room. But I had become so tripid that for two days and nights I remained glued down to where I was.

During this tortuous confinement I received warnings of various sounds in the room from time to time. Muffled footsteps and bubbling roar of gushing water were the common among them. Sometimes a soft and incoherent music would fill the room to the accompaniment of hectic pittar-pattar of treading feet.

Griping hunger made me to stir out after all. When I emerged it was all quiet in the broad daylight. I crawled scruffily and felt terribly uneasy upon the glossy floor. The air was good and reminded me of sweet inflorescence.

As I stood stock taking, I felt the very "tap" "tap" of approaching footsteps. I slunk hurriedly behind the door and partly ascended the wooden frame. Somebody came in humming and droning. Through a tiny chink in the door I spied curiously and atonce recognized the intruder. It was the stately Mem Saheb of the house. I had seen her many a time from the Bougainvillaea that hung over the portico and the hedge along the track on which she often strutted like a goose.

I was overwhelmed with awe to find myself and the Mem Saheb in the same room. What if she chose to fold the door and found me lurking behind it ? She would certainly not let me go unharmed. I, however, did not suffer from lack of confidence in my own potentialities. I would ward her off in the first instance by a mere display of my raised distended head amid hissing warnings. Such a conduct on my part always served as a preliminary weapon. Physical grappling and the venomous jab were things I preferred to avoid except in very desperate situations.

But fortunately the Mem Saheb withdrew after making a little splash of water at the tap.

As I moved I felt something bristling against my belly. I recoiled abruptly and found a small opening between the wall and the door frame. With a view to scan it I placed my sensitive nose on it. A bleak wind blew from inside it. I let my head into it and discovered that there was a convenient tunnel bored through the wall. I went ahead rather sceptically but to my great relief I soon found myself out in the open air among the weeds. This secret entrance must have been carved out by some of my predecessors, that's what I thought.

For a few days I remained busy feeding in the garden and by the scullery sink. A strange phenomenon drew me again to the Mem Saheb's bathroom. The cosiness of its surroundings and the secret passage in the wall made me choose it as my alternative abode after the loss of the fuel godown. In a few days I grew familiar with the rather fixed timings of the Mem Saheb's visitations in the bathroom. This enabled me to move about at other times almost undisturbed and to ramble in the nearby apartments as well.

Here food for me was liberally available. In obscure places such as behind the cabinets and the book shelves there were plump lizzards and other palatable insects. Screeching mice also scurried about in the night. Being unwary of my presence in the rooms they often fell easy victims of my adroit strategy.

Besides, however, my normal grub I occasionally found something else to eat in the Mem Saheb's pantry stores. The opportunity to eat came in handy when the Mem Saheb was asleep and the servants had retired. Whenever, by chance the shutters of the almirahs were left open or insecurely placed, I stole inside and enjoyed an unhampered repast on creams, cheese, cold and grilled meat.

It happened one day that I partook rather avidly and swallowed substantial chunks from a palatable mound of meaty dish and badly mutilated its ornate form. The next day I found the servants busy in ransacking all the nooks and corners of the house and killing every mouse they met!

Apart from the pantry and the bathroom, something often lured me to turn into the Mem Saheb's dressing and the sleeping chambers. The maddening aroma of her costly cosmetics almost infatuated me. I grew crazy to the soft touch of the rich carpets on the floor. Her sleeping rostrum was a piece of princely luxury with foam mattresses overspread with dainty linens. Ocassionally I used to like to feel the softness of her bed by raising my head and placing it on the puffed silken pillows. From there I almost felt the warmth of the Mem Saheb's breath and saw the rhythemic rise and fall of her heaving breasts.

One day I committed an indiscretion which nearly cost me my life. In a playful mood I entered the Mem Saheb's wardrobe almirah and in the velvet folds of her scented garments I felt so completely lost that at dawn I forgot to retire to my secret tunnel.

After her usual bath, the Mem Saheb fumbled in the wardrobe and drew a few pieces out. I was stunned with fear and had nervously resolved to inflict the deadly blow on the intruding hands. Just as I wavered my fangs and held the glands up to pour down the golden juice of death, the Mem Saheb withdrew and locked the almirah in her characteristically unruffled poise.

I was a prisoner and had no escape. For a number of days the wardrobe was not opened and it seemed to me as though the Mem Saheb was not in the house. During this unhappy incarceration, I moulted and shed a whole length of my scales. Prolonged starvation and lack of fresh air had made me sick and emaciated.

Fortunately, one morning the doors of the wordrobe almirah were opened by the Mem Saheb herself. Cold air touched my nostrils and gave me the rare delight of breathing. The Mem Saheb stood there rearranging her apparels and as she worked she blew a soft whistle of peace and content. As was my wont at such junctures, I lay concealed and immobile deep in the fabric folds. To my great chagrin, the Mem Saheb suddenly bawled out in deep agony and darted out yelling "Snake......snake......".

I was taken aback and my heart began to pound heavily. The situation was inexplicable. I had done nothing and had no doubt about my obscurity from her vision. It suddenly

dawned on me that she must have seen my discarded scales. I was so disgusted at my own stupidity and the injudicious application of my otherwise infallible craft. In raging anger I sprang aloft – my agitated head lashed painfully against the wooden panel. Resting my whole weight on the tail end I suspended my body in the air until my white belly touched the rug on the floor. In a few seconds I had passed to safety through the secret tunnel. I cannot tell how that episode ended with the Mem Saheb.

But that incident undoubtedly made the Mem Saheb very suspicious and panicky. All bushes and grass from the compound were instantly cut back and massive wire netting was affixed to the drainage vents. From these hectic anti-snake measures it became abundantly clear to me that nobody had yet unearthed my secret passage in the wall. So at night I again entered the Mam Saheb's bathroom.

The moment I landed in the bathroom a strange premonition occurred me. Perhaps I had walked into some wicked human snare. As I lifted my head to retrieve from my predecament a shaft of dazzling light fell on me and then the room was flooded with brilliant light. Instantly I spied the emergence of two stalwarts clutching bent sticks and closing in on me.

The situation was desperate for me. I puffed and heaved and rose blusterously on the tip of my powerful tail. In burning rage I flourished my head at the guileful adversaries. For a moment the men wavered under my blinkless gaze and looked on with horror in their eyes at my weird dance of death. For me that was the crucial moment to strike and to win the battle. I snapped and bullied with a volley of hissing abuses. The men reeled back.

But an unsuspecting blow suddenly fell on my neck which almost at once floored me I tried to rise again but successive well measured blows prevented me from doing so. Blood oozed from my nostrils and I fainted.

When I came to, I found myself slung across the branch of a tree. My whole body ached with bristling pain from gaping wounds. My assailants had evidently left me for dead. But needless to say that we cobras of the royal lineage can recover phenomenally from our injuries !

KITCHEN-GARDENING FOR FOREST OFFICERS IN INDIA

BY BHARAT SINGH, B.SC. (AG.), A.I.F.C. (HONS.)
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SUMMARY

This article lays down a practical kitchen-gardening scheme for an average Indian family. The scheme is flexible and can be modified to suit particular sets of conditions depending upon the size of the family and area of land available for the purpose.

Introduction—The food problem of our country is not only quantitative but also qualitative. It is said that we have attained self-sufficiency in bulky food materials like cereals and pulses but we can never neglect fruits and vegetables which supply such essentials of life like vitamins and minerals, in the absence of which we are sure to be subjected to physical ailments. According to Dr. Ackroyed, a well balanced diet must contain 2 oz. of fruits, 4 oz. of leafy and 6 oz. of non-leafy vegetables per head per day.

Most of our forest officers have to live in lonely places, far from cities and towns, and it becomes a problem for them to get supplies of fruits and vegetables even once a week, a daily fresh supply being out of the question. The solution of this problem lies in Kitchen-Gardening, which means growing of fruits and vegetables within residential compounds.

This practice has manifold advantages. Firstly, we get fruits and vegetables to suit our taste and requirements; secondly it relieves the overworked cultivator from producing vegetables for forest people and thus the area and labour now devoted to growing vegetables will be diverted towards the growing of cereals and other crops; thus we would help in the "Grow More Food" campaign. Moreover, it is a great pleasure to have on our dining-table vegetables grown in our own back-yard and with personal labour and attention. The freshness of such supply, as compared with the supply got from the market, is both pleasing and wholesome. Above all a kitchen-garden has considerable educative value to children and the other members of the family.

The kitchen-garden is a regular feature of most Indian households, but owing to lack of information on the subject it is generally complained by housewives "we have so many tomatoes that we do not know what to do with them; children are tired of them and are complaining". The reason is that the present kitchen-gardens are not properly planned and all vegetables become ripe at about the same time. With systematic planning and proper management practically all the requirements of fresh vegetables and fruits of an average household can be met from a small plot of land. Most houses in the forests can conveniently find this land either in one block or in two or three patches, and such houses will also have suitable facilities for water from the general drainage system of the household. If these facilities are carefully utilized, they will make a substantial contribution to the health, happiness and economy of the household of a forest officer.

To achieve sucess in this art the following points are of practical value:

Plot size and lay-out—A convenient size of such a garden will depend upon the size of the family and the land available. In order to supply a fair amount of fresh vegetables, say nearly 4 lb. for an average family of six adults almost daily, we need a plot of nearly 3,000 sq. ft. in area, the length and breadth may be varied according to the circumstances. Smaller plots may also be used but they will have to be cultivated more intensively.

The lay-out of such a plot depends upon the character of the particular piece of land, its extent, etc. The lay-out should be convenient and as far as possible attractive. As various kinds of vegetables will be grown at different times, the land has to be laid out in small plots and pathways have to be provided. On page 350 the suggested lay-out for a plot of 100 × 30 feet is given.

Fruit trees like plantains, papayas and climbers like beans and gourds are planted on the sides so that they may not interfere with the growth of other bushy plants. The remaining land is divided into 6 main blocks of 24 × 12 feet, each of which has been sub-divided into smaller plots each roughly 12 × 8 feet; this is a suitable size for instalment sowings which provides the daily vegetable supply of an average family.

The above diagram also works as a vegetable-calender for maintaining a continuous supply throughout the year. Where the requirements are less and facilities are insufficient, the programme can be modified to suit these conditions; for example where water-supply is insufficient during summer, the growing of summer vegetables may be partly given up.

Seasonal Planting and choice of varieties—We have in India three main seasons in a year. They are the monsoon, the winter and the summer; these extend roughly from June to October, November to February and March to May, respectively. In order to have some vegetables growing in our plot throughout the year, it is desirable to divide the plot into 3 or 6 main blocks—then planting and harvesting can be arranged in rotation. It is not a good practice to have any plot under continuous cropping, lest the plot loose its fertility. Every plot should have some rest each year.

While planting in each season at least one leaf, one fruit and one root vegetable must be included for the sake of variety. Each of the sub-plots mentioned above can be so rotated that every kind of vegetable (fruit, leaf and root) may be grown throughout the year in one or two plots.

As regards varieties there is a wide range of vegetables suitable for growing in each season. It is necessary to make one's choice of what to grow with due regard to such factors as the likes and dislikes of the family, the nature of the soil and the space available. Some people do not like carrots; pumpkins cannot be grown in a limited space, etc. While chalking out the above plan every care has been taken that every vegetable common in India could be included in it.

How much to sow—An average family consisting of 6 adult members would require about 4 lb. of vegetable at 10 oz. of vegetables and fruits per adult per day. If there are eight varieties in bearing in the garden, about half a pound a day is all that is required of one kind and a plot of 100 sq. ft. well cultivated and manured can produce this quantity. It is essential to sow the same varieties in two or three such plots at intervals of 3 or 4 weeks to give a continuous supply during the season; for example in the programme suggested *above* Ladies-finger will be sown 5 times, brinjals 4 times, onion, radish can be sown mixed with other vegetables of longer duration like brinjals and cabbages. Coriander or mint may be sown on the sides of beds.

Field preparation—The selected piece of land should be well dug out. All wild growth and weeds should be cleared. The soil should be worked up thoroughly to make it loose to a depth of about 8 to 10 inches. This is preferably done during summer, and the land is allowed to remain open till the break of monsoon. Later on field preparations should be done according to the requirements of the vegetable sown.

Seeds and raising of seedling—To get the best out of our kitchen-gardens it is necessary to grow the best varieties and to use the best seeds. In the beginning the seeds should be

Snakegourd, Bottlegourd, Spongegourd and Bittergourd	1 June to 3 December
,, ,, (Second Sowing)	2 July
Water and Muskmelon	1 January to 2 April
Bottlegourd, three pits, at one end	2 March to 1 August

Chilli	2 June to 2 Jan.
Kheera	1 Feb. to 1 May
Maize	2 June to 2 Sept.
Radish, Carrot, Beet, Turnip	1 Oct. to 2 Dec.
Onion	2 Dec. to 1 April
Groundnut	2 June to 2 Oct.
Potato	2 Oct. to 1 Feb.
Lady's Finger	2 March to 2 June
Brinjal and Onion	1 July to 2 Jan.
Lady's Finger	2 Jan. to 3 April
Swordbean	2 June to 2 Nov.
Radish, Carrot, Fr. Bean	3 Nov. to 1 March
Kheera	1 March to 2 June
Kakri	2 June to 1 Oct.
Brinjal and Onion	1 Oct. to 1 April
Lettuce and Coriander	1 July to 1 Oct.
Cauliflower and Onion	2 Oct. to 2 Feb.
Spongegourd	2 Feb. to 1 July
Cabbage and Onion	3 Oct. to 1 March
Pea	3 Oct. to 3 Jan.
Brinjal	1 Feb. to 2 June

Lady's Finger (E)	2 June to 2 Sept.
Tomato	1 Oct. to 1 March
Leafy Veg.	1 March to 2 June
Cluster bean	1 July to 1 Nov.
Tomato	2 Nov. to 1 April
Dilpasand	1 April to 3 June
Lady's Finger (L)	2 July to 2 Nov.
Chilli	3 Nov. to 1 July
Turnip and Carrot	3 July to 2 Oct.
Lettuce and Celery	3 Oct. to 2 Feb.
Cluster bean	3 Feb. to 1 July
Tomato	1 July to 2 Jan.
Lady's Finger	3 Feb. to 3 May
Radish, Carrot, Beet	1 Aug. to 1 Nov.
Pea	2 Nov. to 2 Jan.
Leafy Veg.	2 Jan. to 2 April
Knol Kohl and Turnip	1 Aug. to 1 Nov.
Cabbage and Radish	1 Nov. to 1 March
Brinjal	2 March to 1 Aug.
Sweet Potato	1 July to 3 Oct.
Cauliflower and Carrot	1 Nov. to 3 Feb.
Leafy Veg.	3 Feb. to 3 June
Cauliflower (E)	2 Aug. to 2 Nov.
Potato (L)	2 Nov. to 2 Feb.
Dilpasand	1 March to 1 July

Beans .. 2 June to 1 Feb.
Spongegourd .. 2 Feb. to 1 June

6 Papaya trees .. 2 Sept.
(Intercropping possible in 1st year)

← 4′ →

100′

Kundru 4 lines

Ginger 4 lines (1 July)

← 6′ →

5 Plantation or Lemon Trees (1 July)
Mint and coriander on Edges

← 30′ →

N.B.—(The lay-out is not drawn true to scale. The numbers before the months represent the approximate weeks of sowing and harvesting).

'E' in brackets stands for early varieties and 'L' for late varieties.

purchased from some well reputed nursery and later on, as far as possible one should raise one's own seeds. In big cities seeds and seedlings may be procured from Government gardens. It is always a good practice to sow the seeds in one's own nursery prepared on a higher level and then to transplant them rather than purchasing seedlings from nurseries. One should always try to get the best varieties from the point of view of cropping power, time of maturity, quality, etc.

Spacing—Proper distances should be provided for vegetables. The usual distance in case of chillies, brinjals and cabbages is 3 feet apart each way. If they are planted closer than this they do not thrive well and the yield suffers. Close planting results in crowding up which encourages diseases and insects. A proper principle in spacing plants is that the distance between any two plants should be equal to their spread when full grown.

Manuring—In this programme the land is made to produce 2 to 3 successive crops during the year. Such intensive cultivation requires large quantities of manure. To provide this, waste products of the household and cattlebarn sweepings can be easily composted and this may be supplemented by fertilizers like Ammonium sulphate, wood ash, bonemeal and oil-cake. The compost prepared from the dung and urine of a cow would be sufficient for the above plot. Cattle manure is considered to be the best and it is also the easily available manure for this purpose.

The plot should be well mixed with organic manures before the break of monsoon. About 5 cart loads of farm yard manure would be sufficient for the above plot. Cake and chemical fertilizers may be used as top dressings.

Irrigation—With proper attention to manuring and mulching we can reduce the water requirements but we cannot totally eliminate it when we are following such an intensive programme. Water supply can be considerably augmented by collecting all the waste water from the house and the Kitchen and utilizing it particularly for plantations and papayas. A Kitchen-Garden of the above dimensions can be maintained from the limited supply of the drainage system or a tap if some arrangement is made for storing water. In the dry season water supply is the chief factor that decides the extent of the kitchen-garden.

After care—The plot should be worked up and all weeds removed as frequently as possible. A small plot well kept and well worked will give more satisfaction than a larger area which is neglected. Plants have as many diseases as human beings. There are insects which attack them and eat their leaves and fruits. Each insect and disease has its own remedy, but if we keep the plants in good health – by a free supply of manure, water, air and sunshine, most plant diseases and pests can be prevented.

Labour and personal attention—The working of the plot on the lines described above should not, however, require an undue measure of time and labour. The planting and sowing are done in small beds and at intervals so that there is no rush of work at any time. It should, therefore, be possible for an average family to manage all the work of the kitchen-garden among themselves assisted by the usual servants of the household. The success of the kitchen-garden will be assured if the exuberant energy and enthusiasm of the younger members of the family can be diverted to it. It is both a pleasure and recreation to work in one's garden along with his children.

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FORMATION OF OXALIC ACID FROM SAWDUST OF DIFFERENT WOODS

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SUMMARY

Sawdust obtained from a few common varieties of wood found in India was fused with sodium hydroxide under optimum conditions for the production of oxalic acid. *Dalbergia sissoo, Pinus longifolia, Dysoxylum malabaricum* and skin of *Saccharum arundinaceum* gave higher yields than the rest of the materials examined. Partial replacement of sodium hydroxide by sodium nitrate up to a certain limit increased the yield of oxalic acid.

Othmer *et al** have worked out optimum conditions for the production of oxalic acid from sawdust. Keeping in view the efficient recovery of sodium hydroxide which is the most expensive raw material used, the optimum conditions are : ratio of sodium hydroxide to sawdust, 3 : 1 ; concentration of sodium hydroxide, 50 per cent ; time and temperature of fusion, 3 hours and 200–220°C. ; depth of fusion mass 0·25 to 0·5 inch. The yields obtained and the amounts of caustic soda recovered are considered to be high enough to permit profitable operation of such a process. The yield of oxalic acid is reported to be dependent upon the cellulose content of the wood.

It was thought of interest to carry out similar fusions with a few common varieties of wood found locally in this part of the country and to determine the yield of oxalic acid under the optimum conditions. This study is likely to give some information regarding comparative cellulose contents of different types of wood as well.

EXPERIMENTAL

Samples of sawdust from 10 different species of wood were obtained. Seventy-five grams of each sample (on the dry basis) was mixed with 225 grams of caustic soda, dissolved in 450 c.c. of water, in a cast iron vessel with constant stirring. The thickness of the mass was about 1 inch. Air was blown over the mass while fusion was taking place since such a treatment has been shown* to give the same yield as obtained by fusing the mass in thin layers. The time of fusion was three hours and the final fusion temperature was only a little higher than 200°C. The same changes were observed during the fusion process as reported by Othmer *et al.* The reaction became exothermic at about 180°C. Heating was then stopped and some sand was added with constant stirring to avoid undue rise of temperature which was maintained as near 200°C. as possible and at no time exceeded 210°C.

The fused mass was discharged into a trough containing water. After filtering, the solution was made to a known volume and an aliquot was taken for the estimation of oxalate ions. For this purpose the solution was first decolorized by warming with activated charcoal. The oxalate ions were then precipitated as calcium oxalate in alkaline medium in the usual way. The precipitate, after washing, was dissolved in dilute sulphuric acid and the oxalic acid set free was titrated against a standard potassium permanganate solution.

RESULTS AND DISCUSSION

The results obtained with different varieties of wood are given in Table I. In some of the samples replicate determinations were made to test the reproducibility of the results which is seen to be fairly good. *Dalbergia sissoo* (*sissoo*), *Pinus longifolia* (*chir*) and

* Othmer, D. F., Jacobs, Jr., J. J. and Pabst, A. C., Indust. Eng. Chem., 34, 261 and 268 (1942).

Our thanks are due to Dr. D. Narayanamurti, Chief Research Officer, Forest Research Institute, Dehra Dun for supplying some of the samples of sawdust included in these investigations.

Dysoxylum malabaricum (*white cedar*) give higher yields than the rest of the materials which all give a value of about 30 ($\pm$ 2) per cent. It is interesting to note that the skin of *sarkanda* (*Saccharum arundinaceum*) gives a better value than that given by its pith.

Since sodium hydroxide is rather a costly raw material, its replacement in part at least by a less expensive reagent is likely to make the process more economical. A few experiments were, therefore, made in which one of the samples of sawdust was fused with mixtures of sodium hydroxide and sodium nitrate, keeping the total weight of the compounds the same in each case. The results given in Table 2 show that the yield obtained by substituting sodium nitrate for sodium hydroxide up to a certain limit actually increases the yield of oxalic acid. Since sodium nitrate costs only half as much as sodium hydroxide the reaction deserves further examination.

TABLE 1

Formation of oxalic acid from different varieties of wood

No.	Botanical name of the wood	Trade name of the wood	Local name of the wood	Oxalic acid formed (% of dry wood)
1	*Cedrus deodara* ..	*Deodar* ..	*Diar* ..	31·5, 32·1
2	*Dalbergia sissoo* ..	*Sissoo* ..	*Tali* ..	38·5
3	*Albizzia lebbeck* ..	*Kokko* ..	*Shirin* ..	28·1, 28·5
4	*Eugenia jambolana* ..	*Jamman* ..	*Jamman* ..	29·8, 30·39
5	*Pinus longifolia* ..	*Chir* ..	*Chir* or *Chil* ..	38·5, 39·3
6	*Dysoxylum malabaricum* ..	White cedar ..	*Vellagil* (*Mal*) ..	37·98
7	*Artocarpus-integrifolia* ..	Jack ..	*Canthall* ..	29·1
8	*Cedrela toona* ..	*Toon* ..	*Toon* ..	30·1
9	Pith of *Saccharum arundinaceum* ..	Pith of *Sarkanda*	*Kane ka Guda* ..	30·3
10	Skin of *Saccharum arundinaceum* ..	Skin of *Sarkanda*	*Kane ka Chhilka*	41·5

TABLE 2

*Effect of partial substitution of sodium hydroxide by sodium nitrate on the yield of oxalic acid from wood**

No.	Wt. of dry sawdust	Wt. of caustic soda	Wt. of sodium nitrate	Oxalic acid formed (% of dry wood)
	gms.	gms.	gms.	
1	75	225	Nil	38·5
2	75	200	25	40·7
3	75	180	45	43·0
4	75	160	65	37·0

* *Dalbergia sissoo* was used for these experiments.

DESIGN OF BANDSAWS

BY J. BANERJI, I.F.S.
Chief Conservator of Forests, Andamans

A Clark Band Saw Mill with 8′ wheel, taking a 14″ saw, is currently under erection at Chatham, Port Blair, Andamans. In the meantime, however, it has been possible independently to set up a 54″ Fay and Egan Band Mill, supported with a 60″ White Resaw. There are two 44″ Ripsaws with two 30″ single cut-off pendulum trim saws at the out-turn end. A Clark five-saw edger has recently been installed behind the 54″ Band Mill. The mill has been fully motorized.

2. An electrically operated chain log-haul supplemented with a steam nigger and a kicker brings the logs from rafts in the sea direct to the 18 feet log carriage, which is of the head-block type. The knees are operated manually with levers by three 'doggers' riding on the carriage. Single-bar top and bottom dogs, 'boss' dogs, and 'hammer' dogs are used to keep the log firm in its position while cutting. To obtain the maximum out-turn of first grade planks and boards from logs of valuable species, the logs are turned three to four times with the help of a winch and overhead pulley. Turning is reduced to a minimum for less valuable species where better grades do not yield a corresponding increased return.

3. The conveyor system consists of live and dead rolls inside the mill. At the green end there is a conveyor chain, which brings the sawn out-turn from the trimmers directly on push trolleys moving on 24 lbs. rails. An overhead 5 ton gantry picks up the load, dips it in a mixture of anti-stain solution, and deposits the unit loads over older stacks for air-seasoning.

4. The lay-out is, therefore, modern, and provides only for minimum handling of lumber both inside and outside the mill. The main difficulty has been the absence of a qualified saw-doctor, conversant with the sawing of Andamans hardwoods. This Sawmill has to cut logs of about a dozen species, – very hard, hard, medium, and soft, flowing into the mill in a bewildering succession. The complexity of the problem can be easily appreciated, when one remembers that the Mill Manager, in addition to his other duties, has to decide upon the shape and pitch of saw-teeth, the tension to be given to the saw, the swage and gullet space required, the speed of the saw, and the speed of the carriage, separately for different depths of cuts in different species of woods. Quick decision on these abstruse matters had to be taken after a series of initial exploratory experiments.

5. When an ammeter was connected to the saw it was found that it was using 28 amps while running freely (equivalent to 22·4 H.P.); while cutting Padauk 6½″ deep, at speeds varying from 56 ft. to 160 ft. per minute, the consumption varied between 40 amps (32 H.P.) and 56 amps (44·8 H.P.). There were similar variations for different species, different depths of cut, and different speeds of feed, different types and pitch of teeth, and with different strains on the saw. A close study of the variations gave us a clue to find out the fundamental relations in sawing with a bandsaw.

6. Let the broken parallel lines in Fig. 1 show the path of the teeth of a bandsaw through a cant on the log carriage. Points A, B, C, D, E, F, G, are the successive teeth of the saw moving downwards. Teeth F and G have already passed through the cant, which is moving to the left, C is just entering it, while A and B are still to meet the log. Similarly A′, B′, D′, E′ and G′ are the points respectively where the teeth come in contact and enter the cant. The teeth D and E entered the cant at D′ and E′ respectively and followed the lines D′ D, E′ E, on the sawn surface, and will follow D D″ and E E″ in cant. The tooth C is just

entering the log at C and will follow the path C C″ in space. Similarly B and A will follow respectively the paths B′ B″, and A′ A″ through the cant, if the speed of the log carriage remains uniform.

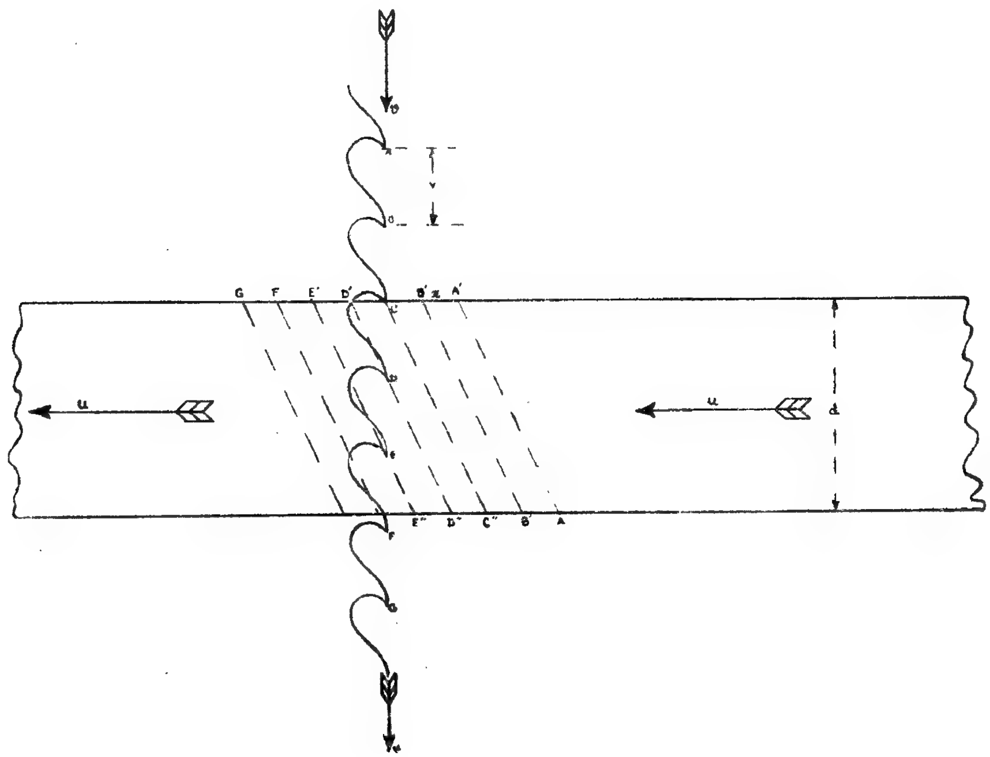

FIG. 1.

7. Let

x = the bite of the saw per tooth,
y = the pitch of the teeth,
u = the velocity of the log carriage,
v = the velocity of the saw.
(If d = diam. in inches of wheel
n = number of revolution per min.

then $v = \frac{\pi}{12} d \cdot n \cdot = 0 \cdot 2618\ d \cdot n$ ft./min.)

t_1 = time taken by log carriage to cover a horizontal distance x
t_2 = time taken for the tooth to cover a vertical distance y

Then $t_1 = \frac{x}{u}$ .... (i)

and $t_2 = \frac{y}{v}$ .... (ii)

As the optimum bite for each tooth under a set of given conditions should remain uniform, we must by definition have $t_1 = t_2 = t$ (say), i.e., the time taken by the log carriage to cover the distance of the bite, should be equal to the time taken for the tooth to cover the distance of the pitch. The tooth C is entering the log at C; after a time 't' B' will come to the position C, and at the same time tooth B will arrive at C. After a time 2 t, the tooth A will arrive at C, and at the same time the point A will be at C. The dotted lines in Fig. I, show the path of the teeth in space, through the log.

8. From equations (i) and (ii) above, and from the definition of the bite of a tooth, we get

$$\frac{x}{u} = \frac{y}{v} = t \quad \text{(iii)}$$

This is the fundamental formula for bandsaws. From this we get the following relations :

$$x = ut = x\,(u, t) \quad \text{(iv)}$$

$$y = vt = y\,(v, t) \quad \text{(v)}$$

$$\frac{y}{x} = \frac{v}{u} = m \quad \text{(vi)}$$

$$vx = uy \quad \text{(vii)}$$

From (vi) we get $y = \frac{v}{u}\, x = y\,(x, v, u)$

$$\therefore \quad dy = \frac{\delta y}{\delta x} dx + \frac{\delta y}{\delta v} dv + \frac{\delta y}{\delta u} du$$

$$= \frac{v}{u} dx + \frac{xdv}{u} - \frac{vx}{u^2} du$$

$$= \frac{uvdx + uxdv - vx\,du}{u^2} \quad \text{(viii)}$$

It shows the change in the pitch due to small changes in x, v and u.

Similarly from (vi) we get $x = \frac{u}{v}\, y = x\,(y, v, u)$

$$\therefore \; dx = \frac{\delta x}{\delta y} dy + \frac{\delta x}{\delta v} dv + \frac{\delta x}{\delta u} du$$

$$= \frac{u}{v} dy - \frac{uy}{v^2} dv + \frac{y}{v} du$$

$$= \frac{uv\,dy + vy\,du - uy\,dv}{v^2} \quad \text{(ix)}$$

This equation shows the effect of small changes in y, u, and v, on x, the bite per tooth. Assuming some of the variables to be constant we also get the following relations from (vi) :

$$\left.\begin{array}{ll} \frac{\delta x}{\delta u} = \frac{y}{v} = t & \frac{\delta y}{\delta u} = - \frac{vx}{u^2} \\[1ex] \frac{\delta x}{\delta v} = - \frac{uy}{v^2} & \frac{\delta y}{\delta v} = \frac{x}{u} = t \\[1ex] \frac{\delta x}{\delta y} = \frac{u}{v} & \frac{\delta y}{\delta x} = \frac{v}{u} \end{array}\right\} \quad \text{(x)}$$

These equations show the effects on x and y respectively, due to a small change in u, v, x, and y, individually, when the other variables are assumed to be constant. It will be noticed from (vii) and the above relations, that, other things remaining constant, (i) increase in the speed (u) of log increases the bite (x), but decreases the pitch (y) ; (ii) increase in the speed (v) of the saw increases the pitch (y), but decreases the bite (x). As the pitch and velocity of saw cannot be readily altered, the velocity of feed and the bite for tooth are usually varied to suit the different problems faced daily in sawing by the sawyer.

9. The volume of sawdust is more than the volume of timber from which it is produced, and a safety factor of 3 is usually retained.

If

g = area of the gullet

k = kerf of the saw

then the gullet space is gk.

The volume of the timber that is converted into sawdust will be readily seen from Fig. I. The tooth C cuts the area D′ C C″ D″ and collects it in the gullet space between C and D. Similarly B will cut the area C B′ B″ C″, and carry it within the gullet space between B and C. If 'd' is the depth of the cut, the area of the parallelograms of cut = $x \cdot d$; and if the kerf = k, the volume of each bite of wood = $x \cdot d \cdot k$.

$$\therefore \quad 3\,x \cdot d \cdot k = gk$$

$$\therefore \quad g = 3xd = 3\,u\frac{yd}{v}, \text{ from (iii)} \quad \text{(xi)}$$

$$\text{Or} \quad u = \frac{gv}{3yd} \quad \text{(xii)}$$

Formula (xi) is the second fundamental equation for bandsaw and gives the minimum gullet space necessary under given conditions of speed (u) of feed, speed (v) of saw, pitch (y), and depth (d) of the cut. Formula (xii) gives the maximum speed of feed permissible under the same conditions. Increase of gullet area and speed of saw will permit increased feed, but increase of pitch or depth of cut, other things remaining constant, tends to reduce the speed of feed. Hence the gullet area and the shape of the tooth are the critical factors in increasing production.

10. From (xi) we get

$$x = \frac{g}{3d} \quad \text{(xiii)}$$

But the gullet area is given by the area of the curve (see Fig. II) of the teeth above the horizontal axis OY.

If the shape of the tooth is given by the curve $z = f(y)$, then the area of the gullet

$$g = \int_0^y f(y)\,dy, \text{ where y is the pitch}$$

$$\therefore \quad x = \frac{1}{3d}\int_0^y f(y)\,dy \text{ from (xiii)} \quad \text{(xiv)}$$

As the value of the definite integral (xiv) partly depends on the pitch (y), this formula gives a relation between the pitch and the bite, provided we can find f (y). The curve is a straight line up to the point Z_1 ($Z = m_1 y$, where $m_1 = \tan\theta$, θ being the clearance angle, usually 15°). The portion $Z_1 Z_2$ is parabolic ; at Z_2 there is a point of inflection, marking a change of curvature from convex to concave downwards as we proceed from left to right

on the rising curve. At Z_2, $f'(y)$ is positive, $f''(y) = 0$, and $f''(y)$ changes its sign from positive to negative as 'y' increases through the value y_2. Hence $f'''(y)$ is negative. From Z_2 to Z_4 the curve is almost a circle, or broadly elliptic. The maximum depth of gullet occurs at Z_3, where $f'(y) = 0$, and $f''(y)$ is negative. The portion $Z_4\, y_5$ is a straight line, $Z = m_2 y$, where $m_2 = \tan \phi$, ϕ being the sum of angle of sharpness ($= 45°$) and angle of clearance ($= 15°$). At y_5 there is a sharp point. The curve, though continuous, is not smooth, and is oscillating. The hook angle is the complement of ϕ.

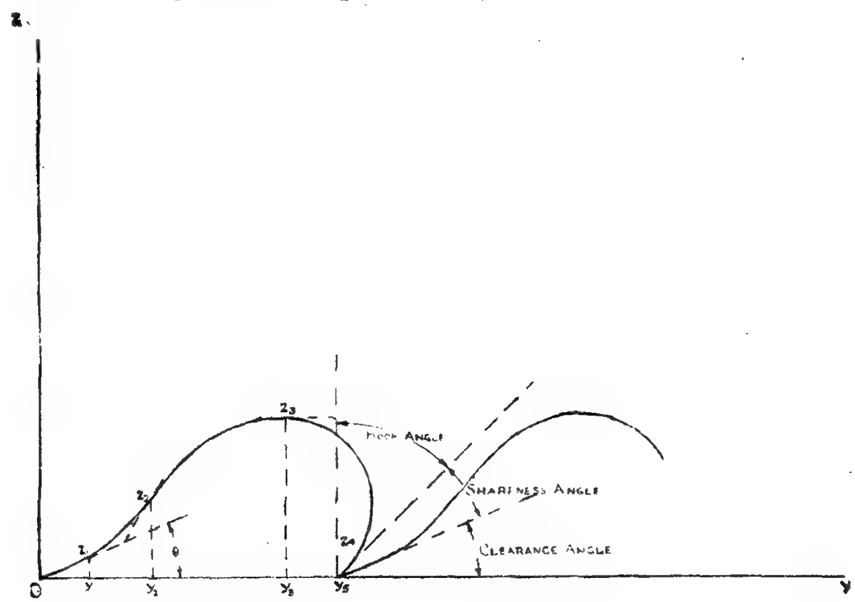

FIG. II.

11. The interpretation of these results is further complicated by practical considerations :

(i) With the increase in the depth (d) of saw cut, the speed (u) of the log carriage has to be reduced, while no change in the pitch (y) is usually possible.

(ii) The speed (v) of the bandsaw cannot be altered during normal operations.

(iii) While the pitch (y) and speed of saw (v) usually remain constant, the speed of the carriage (u), and consequently x, the bite (= ut) varies considerably.

(iv) The pitch (y), the saw speed (v), the gullet generally remain the same for hardwoods as well as 'soft' woods. Only the speed of feed can be readily adjusted.

A practical remedy is to use different saws with different pitches for different species ; but this introduces many management problems.

12. The relation between the different variables may be exhibited in a diagram obtained from the fundamental equation $y = \frac{v}{u} x = mx$....(from vi). This equation contains a single parameter m ; hence the equation f (x, y, m) = O represents a system of straight lines passing through the origin, each with a different value for m. As $m = \frac{v}{u}$, this system of straight lines represents all possible combinations of x, y, v, and u.

13. In Fig. III, let the x — axis represent the bite, and y — axis, the pitch. The system of straight lines f (x, y, m) = O is represented by the lines I, II, III, etc., with values

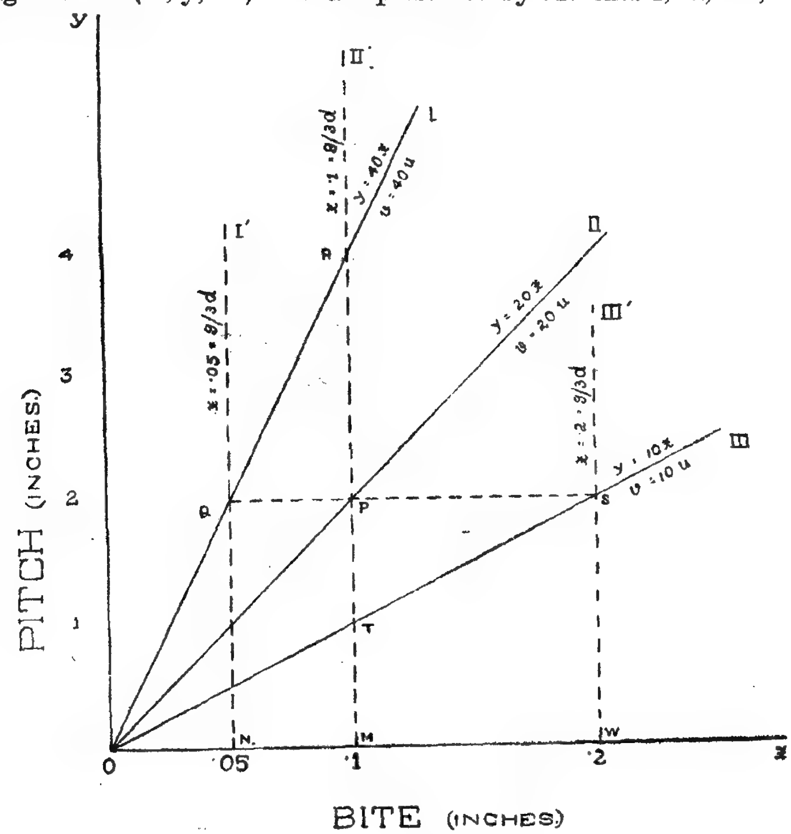

FIG. III.

(say) of m equal to 40, 20, 10, etc., respectively. Needless to say that there will be an infinite number of lines corresponding to the different values of 'm'. As $m = \frac{v}{u}$, for each value of m, there will be, theoretically, an infinite combination of values of v and u. Similarly let I^1, II^1, III^1, etc., be another system of straight lines parallel to y — axis, represented by the general formula f (x, λ) = O, with λ = 0·05, 0·1, 0·2 respectively, where λ is a variable parameter equivalent to $\frac{g}{3d}$....(from xii). For each value of λ there will be, theoretically, an infinite combination of values of 'g' and 'd' ; but if we assume the depth of cut d to be constant, (say 6″) the changes in the values of g, the gullet area, may be more readily visualized with the change in bite. If the bite x is increased the gullet area g should also be increased, and

vice versa. The required pitch in each case is given by the point of intersection of these parallel vertical lines with one of the inclined lines of the first system.

In Fig. III, let P be the point of intersection of line II of the first system (m = 20) and line II[1] of the 2nd system $\left(x = \frac{g}{3d} = 0 \cdot 1 \right)$, which has been found to be satisfactory for 6″ depth of cuts after experiment. A bandsaw tooth corresponding to this point will have an optimum bite when $x = \frac{g}{3d} = 0 \cdot 1''$. Assuming the saw is cutting 6″ planks (we shall assume this in all the following examples) the gullet area should be $3 \times 6 \times \cdot 1$ or $1 \cdot 8$ sq. inches. Its pitch y should be $PM = 20 \times 0 \cdot 1 = 2$ in. The shape of the tooth and its back should be so designed that with a pitch of 2″, and gullet area of $1 \cdot 8$ sq. inches, the tooth should have a strong base, and should not be so high as to chatter. When such a tooth has been designed, sharpened, swaged, shaped, and the saw is given an appropriate tension, it should, theoretically, saw 6″ planks at a speed of $\frac{v}{20}$, or 400 ft./min. ; if the linear velocity of the bandsaw is 8,000 ft./min. (which will be assumed to be constant in all the following examples). Hardness of the timber, presence of knots, amount of strain, experience of the sawyer, a conservative sense of safety, Horse-Power available to run the carriage, will all tend to reduce the effective actual speed of the log carriage, in practice, to a considerably lower figure, say, 200 ft./min.

(i) When the speed of the log carriage is thus reduced to 200 ft./min. the linear velocity of the bandsaw can theoretically be reduced proportionately to 4,000 ft./min., without affecting the efficiency of sawing. But this is not practically possible owing to the single uniform rate of revolution of the band wheel. As a result, the position of equilibrium is shifted to Q on line I ($v = 40\,u$), where the bite is immediately reduced to ON, or $0 \cdot 05''$. A tooth that is capable of $0 \cdot 1''$ bite, is being used for a bite of $0 \cdot 05''$, i.e., the saw is being used to 50% of its potential capacity. There is more than enough room in the gullet to carry off the sawdust. The correct saw under such circumstances should have, with the same pitch, a gullet area of $3 \times 6 \times 0 \cdot 05$ or $0 \cdot 9$ sq. inches.

(ii) If it is proposed to keep the bite same (i.e., OM), even after reducing the speed of the carriage to 200 ft./minute, the tooth should be redesigned with a longer pitch $RM = 40 \cdot x = 40 \times \cdot 1 = 4''$ which, in practice, will be mechanically an unsatisfactory tooth, as it will have a gullet area of only $1 \cdot 8$ sq. inches, with a pitch of 4″.

(iii) Again suppose a reckless sawyer increased the speed of the carriage from 400 to 800 ft./minute, thus transferring the position of equilibrium to S on line III ($v = 10u$). Immediately the bite is increased to $OW = 0 \cdot 2''$. The gullet area for this bite should be $= 3 \cdot d \cdot x = 3 \times 6 \times 0 \cdot 2 = 3 \cdot 6$ sq. inches to convey all the sawdust. But as the gullet of the saw in this case is only $1 \cdot 8$ sq. inches, the sawdust produced will not be removed, and in the insufficient space available for it, it will choke the saw, which might snap.

(iv) If the speed of log carriage is reduced to 200 ft./minute, and the speed of bandsaw to 2,000 ft./min. (which is not usually possible), the new point of equilibrium is T on line III ($v = 10u$) with the original bite $OM = \cdot 1''$. But at this point the pitch should be $TM = 10 \cdot x = 1''$, with a gullet area of $1 \cdot 8''$. It will perhaps be difficult to design a tooth as strong as P, with the same gullet area, but a smaller pitch TM. The depth or gullet may be too deep making the teeth weak and chatter.

(v) The best position of P can, therefore, be found by long experience for each depth of cut of each species. A considerable amount of trial and error is involved. There is no unique mathematical solution of the problem : the most satisfactory position may be located inside a circle round P with a small radius, which may be called the circle of optimum positions.

14. There are certain well-recognized standards for the different dimensions of teeth, pitch, etc., beyond which it is not safe to stray. Within these limits, there are hundreds of combinations for pitch, depth of gullet, hook, clearance, shape of the back, etc. Thus 'y', the pitch varies from $\frac{3}{4}''$ to 3", but normally it lies between $1\frac{1}{2}''$ to 2". It is usual for sawfilers to run the maximum hook (30°) in their saws in order to obtain the maximum chisel effect of the teeth. At the same time, the back of the tooth must be made full and rounded to give sufficient strength to the tooth; consequently the pitch has to be increased to $1\frac{3}{4}''$ to 2" or more. This increased pitch permits of a deeper gullet of $\frac{5}{8}''$ or $\frac{3}{4}''$ circle, which again provides for an ampler gullet space than before. The sawdust can be carried off more easily, and, therefore, a faster feed would be possible, theoretically.

15. The hook angle is the angle between the face of the tooth, and the line perpendicular to the pitch, i.e., the line perpendicular to the straight line joining the tips of adjoining teeth, or hook angle = 90° − (sharpness angle + clearance angle). It usually varies from 15° for hardwoods of high density to about 25° for softwoods. The saw-doctors of fast-cutting bandsaws of U.S.A., and Canada usually prefer a higher hook angle, up to 30°. The greater the hook, the lesser the power required to cut, and the faster the timber can be fed. Too much hook, however, results in rough sawing, and chattering of saw, other things remaining the same.

16. The sharpness angle of the tooth is the angle between the face and the back of the tooth, and is usually 44° or 45°. No, or little, variation should be made from these standards. The most reliable swaging machines are usually fitted with dies and anvils which would take, most effectively, teeth with a sharpness angle of 44° or 45° only. Similarly shapers, and sharpeners, are most efficient on 44° or 45°. Any large deviation will involve rapid wearing away of saw teeth.

17. The clearance angle, i.e., the angle between the back of tooth and pitch line, usually varies between 10° for hardwoods to 15° for softwoods in wide bandsaws. With the modern tendency to run the largest hook (30°), and the sharpness angle limited to 44° or 45°, the choice for clearance angle is usually either 15° or 16°.

18. The depth of the gullet usually ranges between $\frac{3}{8}''$ to $\frac{3}{4}''$ for different pitches, though $1\frac{1}{2}''$ depth with 3" pitch has been used in large modern mills in U.S.A. The depth of the gullet, other things remaining constant, is limited by the strength of the teeth. With the same pitch, the deeper the gullet, the weaker the tooth, and the more difficult it is to provide a rounded back for the tooth. On the other hand, the deeper the gullet, the more gullet space is obtained, and the faster a saw can cut.

19. The bite of the tooth is defined by the length of timber along the log that is being chiselled off by each tooth. It usually varies between ·04" and ·12" depending upon the carriage feed rate, the hardness of wood, and depth of cut, and the horse power available for the machine. The capacity of the gullet to carry sawdust away usually puts a ceiling on the maximum bite per tooth, that can be taken by the saw. It is also said that the bite per tooth is most efficient, when it is between 25% to 50% of the width of swage.

20. The linear speed of the saw usually varies between 7,000 and 10,000 ft./min., depending upon the size of the bandsaw. Higher speeds are used for softwoods and lower for hardwoods. Any speed near 8,000 ft./min. could be correct under average conditions. The speed of feed of cants in the Resaw at Chatham goes up to 250 ft./min.; for the log carriage, the speed may be 100 ft./min. With deep cuts, and with hardwoods, the speed slows down, while with softwoods and small cuts, the speed may be increased considerably, other things remaining the same.

21. Swage set is invariably used in the bandsaw mill at Chatham. Swage is the width of the tooth at its tip. If t = thickness of the sawblade, and s = the swage, then,

$$\text{Set} = \tfrac{1}{2} (s - t)$$

Set should be equal on either side of the blade. For softwoods it usually varies between 0·01″ to 0·02″, and for hardwoods from ·008″ to ·012″, on each side. Increase in set of swage increases the kerf for the same gauge of the sawblade, and thus increases the amount of sawdust. Another simple rule to remember is that the swage of a saw should be twice the thickness of the saw, plus one gauge, or a little more, to compensate for the kerf, which is slightly narrower than the width of the tooth, or swage. The clearance on each side of the saw in the kerf is approximately equal to $\frac{1}{4}$ the width of the swage.

22. Tensioning a bandsaw, which still remains a mysterious cult with each saw-doctor, means giving a curvature to the bandsaw along its width so that it fits snugly on the rim of the wheel, whether flat or crowned, and when strained over the pulleys, the blade remains tight on its edges. The curvature of the crowned rim of the band mill at Chatham was found to be that of a circle with 30 ft. radius, which means that the crown is ·017″ above the edges. With a tension gauge cut to a radius of 24 ft. (height of crown ·029″) it was easy to "tension" the bandsaw. A width of $\frac{3}{4}$″ to 1″ was left "untensioned" on either edge of the blade to provide a "tyre". All 'fast' points were rolled down, and "loose" spots, "lumps" and "twists" corrected. The back of the blade was given a crowning of ·02″ in every 6 ft.

23. Usually the maker of the machine provides a "strain" table, showing the weights necessary for different widths of saws. In its absence, the formula used has been as follows :

> "Multiply width of saw in inches by thickness in thousandths of an inch, and again multiply the product by ten". This gives the strain in lbs.

24. Satisfactory standards of band-mill practice have been set for softwoods like white *Dhup*, *Papita*, etc., with all these experiments. Hardwoods also show better results when changes in the milling practice are effected as indicated by the principles of sawing. The difficult task now is to design a tooth, and adjust the milling practice, in such a way that the same saw will cut reasonably well many, or most, of the different types of hardwoods and softwoods coming daily to the mill. Veteran sawyers may declare this to be impossible. But a blade with the following specification has been found generally satisfactory, when the saw is properly tensioned.

Diam. of wheel	= 54″
Width of saw	= $6\frac{1}{2}$″
Gauge of saw	= 17 S.W.G. = 0·56″
Swage	= 13 to 12 S.W.G. = ·092″ to 0·104″
Pitch of the teeth	= $1\frac{1}{2}$″
Depth of gullet	= 9/16″
Hook angle	= 30°
Clearance angle	= 15°
Sharpness angle	= 45°
Number of revolutions/min.	= 560
Linear speed of the saw	= 7943 ft./min.
Gullet area	= 0·97 sq. inches.

Shape of the tooth ..

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Pathological Note No. 8

NEW AND NOTEWORTHY DISEASES OF FOREST TREES AND DECAY IN TIMBER IN INDIA

(*i*) *Pan·llus rupicola** (Mass.) Singer (*Collybia rupicola* Mass.) a parasite of deodar (*Cedrus deodara* Loudon) in the Central Himalayas.

and

(*ii*) (*a*) *Polyporus palustris*† Berk. and Curt. and (*b*) an unidentified Basidiomycetes attacking spruce timber in the Eastern Himalayas : Collected from the "drift timber" base at Kokilamukh delta of Brahmaputra River, Jorhat, Assam.

BY K. BAGCHEE

Mycologist, Forest Research Institute, Dehra Dun.

(*i*) *Panellus rupicola* (Mass.) Singer

While surveying diseases of conifers and decays in the Chakrata division in the Western Circle, Uttar Pradesh, in the autumn of 1938 and 1939 a group of 16–20 years old pole trees of deodar was noticed dying in a plantation on a slope close to the forest rest-house, Mundali (8,250 ft. a.s.l.), Bawar range. Established on a well-drained, western hill slope of moderate gradients the dying trees were growing in the middle of a thriving plantation, and except for a little over-crowding no external factor appeared to have influenced the casualty. The bark at the base of the dead and dying trees appeared discoloured, sunk, blistered and soaked with resin exuded from the canker. Since no insect was associated at this stage, the symptoms of canker signified that some fungal attack was responsible for the mortality. In 1941 the disease was noticed again in another area in the same range on 15–20 years old trees of natural seedling regeneration growing in a forest which had been thinned two years before. In this case sporophores of some Agarics were observed along the margin of the cankers (Pl. I, Figs. 1 and 2). The incidence of the disease was noticed in 1943 in yet another area, in Chandnigadh block (8,500 ft.) about 26 miles to the north of Mundali where the first attack had been noticed. Recently, in the autumn of 1952, the fungus was recorded in Kasol (7,000 ft.), Parbatty range, Kulu and in Soja (8,000 ft.), Banjar range, Seraj division, Punjab, at the base of young poles of deodar and also on decaying stumps left after the removal of some trees which were observed to be drying up. The sporophores appear initially on the killed sapwood along the edge of the canker in summer, and later on spread over the wood in the hollow cavity of the canker, and finally on the bark surrounding the canker (Pl. I, Fig. 2). After the trees are felled the fungus thrives on the decaying stump as a slash decay (Pl. II, Fig. 1).

The fungus appears to be a potential parasite of deodar and as it occurs in different regions of the inner Himalayas the following description of the biology may be helpful in detecting it and recording its activity in other deodar forests.

Sporophore—Pileus (Pl. I, Fig. 1 and Pl. II, Fig. 1) slightly fleshy, leathery on drying, circular, size, ·5–1 cm. ; margin entire, upper surface soft, villose, old clamp connections present (Text Figs. 2*a*, 2*b* and 2*c*), colour 'yellow ochre', 'buckthorn brown' to 'avellaneous' and 'vinaceous buff' ; stalk eccentric, round to oblong, solid, size 1–2 ·5 cms., tomentose changing to villose with age, colour 'buckthorn brown' to 'cinnamon brown' ; gills sub-decurrent, some forked in the middle radiating towards the margin, appear granular due to the deposit of spores and crystaline exudates, colour 'cinnamon brown'.

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* I am thankful to Dr. R. W. G. Dennis of the Royal Botanic Garden, Kew, London for identifying the fungus and † to Dr. M. K. Nobles, Pathologist, Division of Botany, Ottawa, Canada for identifying the fungus by monosporous pairing of the culture with that of *Polyporus palustris* maintained in the laboratory in Ottawa.

Tramal hyphae thick-walled, branched, septate and with clamp connections (T. Figs. 3*a* and 3*b*), colour 'warm buff', 'antimony yellow' and 'yellow ocher' in mass; binding hyphae indistinct; generative hyphae indistinct; basidia $6 \cdot 0 \times 3\mu$ (T. Figs. 4*a* and 4*b*); spores hyaline (T. Fig. 4*c*), thin-walled, $4 \cdot 5 \times 2 \cdot 0\mu$; sterigmata filamentous, $2 \cdot 5\mu$ long.

Cultural characters—Growth initiates slowly with an imperceptible fringe of hyphae on the inoculum after 24 hours, the character of mycelium changing to sub-hyaline cottony 48 hours after transfer becoming white, long-stapled cottony on the third day. The fungus descends on the plate on the 4th day as appressed, sodden, hyaline mycelium which gradually advances as such during the next few days, i.e., the growing region is hyaline, appressed, sodden followed by sub-hyaline to white aerial and woolly-cottony and long cottony mycelium on the inoculum. The fungus progresses slowly as such till the 11th day, when in a small area around the inoculum, a thin, skin-like crust appears. During the subsequent days the area of the skin-like crust increases as the fungus grows, and is covered with a fresh growth of white woolly-cottony mycelium. The mat in four weeks old culture developed numerous zone-lines which had an entire, sharp, slightly raised margin; colour changing to 'light buff' around the inoculum on the 9th day deepening to 'ochraceous tawny', 'tawny' and 'buckthorn brown' and 'russet' appearing during the four following days. All these colours persist in the four weeks' old mat.

On the heartwood blocks of chir pine (*Pinus longifolia*) under decay tests the fungus produced typical fertile sporophores after 3 months, at 20°–22°C., the stalks appeared as in nature, both in size and character, and the pileus diminutive, otherwise normal (Pl. II, Fig. 3).

Growth (radial) in malt agar media at 20°–22°C.

24 hours	..	Nil
2 days	..	a trace
3 ,,	..	0·5 cms.
4 ,,	..	0·9 ,,
5 ,,	..	1·4 ,,
6 ,,	..	1·9 ,,
1 week	..	2·5 ,,

Covers the plate of 6 cms. diam. in three weeks.

Aerial hyphae thin, hyaline, uniformly branched septate and with whorled clamp connections (T. Fig. 5*a*), $1 \cdot 50$–$2 \cdot 5\mu$ broad; appressed hyphae hyaline, branched septate and with clamp connections (T. Fig. 5*b*), $2 \cdot 5$–$4 \cdot 0\mu$ broad; hyphae from 6 weeks' old mycelium are thick-walled, almost without lumen, branched, septate with frequent clamp connections, thickly woven, fused laterally forming a compact mat (T. Fig. 5*c*) of 'yellow ochre' colour.

Oxidase test—On gallic acid agar diffusion zone very strong, growth nil; on tannic acid agar diffuson zone strong, growth nil; on gential violet agar slight discolouration, growth weak.

Loss of weight of wood blocks in agar culture for 4 months at 25°–26°C.

	Chir sapwood	*Chir heartwood*
Max.	12·11 per cent	9·88 per cent
Min.	8·77 ,,	7·50 ,,
Aver.	10·11 ,,	8·71 ,,

(*ii*) (*a*) *Polyporus palustris* Berk. and Curt. and (*b*) and an unidentified Basidiomycete from "drift timber" base at Kokilamukh, Jorhat, Assam.

During the earthquake of August 1950 in the north of Assam, the epicentre of which was in the remote mountainous frontier of India and Tibet, trees were uprooted and washed down by various tributaries and thrown into the main waterway of Assam, the Brahamputtra River, and finally drifted into the plains. In February 1952 I inspected the delta of the river Kokilamukh, about 3 miles away from the town of Jorhat, where the assorted timbers salvaged during the floods were stocked by the forest department for disposal, and collected, besides sporophores of many species of Basidiomycetes which cause decay of the tropical hardwood timbers, a few samples of some coniferous timbers growing in the inner regions of the Eastern Himalayas and drifted into the plains. Two samples of coniferous wood were taken from logs embedded in the recently deposited alluvium on the bank of the river; both appeared interesting as they showed a brown cuboidal rot, and when incubated in the laboratory produced active mycelia. The fungi were isolated and examined and a short life-history of the fungi is described in the following. Both the samples of the timber were identified by the Wood Technologist, Forest Research Institute, Dehra Dun.

(*a*) Decay in *Picea* sp. (*Picea morinda* probably) due to *Polyporus palustris* Berk. and Curt. : M.* 558* : Culture No. 153-T.

The log was found embedded in the sand bank of the river. The external portion of the timber showed signs of attack by an active fungus producing a brown carbonizing cuboidal rot. After scraping off the friable external layers it was found that the rot was not superficial, the fungus having penetrated into the inner core of the log ; in the intermediate region it progressed more actively along the growth rings where a thin papery mat replaced the disintegrated tissues. The decayed wood removed from the moist environment and air-dried cross-shakes appeared to have separated into small cubes (Pl. III, Figs. 1 and 2). In the centre of the log, however, where the fungus was less active, the initial stage of the rot was indicated by discoloured patches, diffuse brown stains broken up at places by darker elongated streaks.

In the moist chamber in the laboratory the fungus emerged after 6 weeks as thin white mycelia along the growth rings and after about 6 months produced papery mycelia in transverse direction along the growth rings and cross-shakes, the wood falling off as small cubes (Pl. III, Fig. 2) ; but it never produced enough mycelia to cover the wood nor did it produce a fruitbody although the wood was kept for two years till it disintegrated into a pulpy mass.

Cultural characters—The fungus initiates a weak growth on the inoculum after 24 hours as sub-hyaline, cottony fringe and descends on the plate as cottony aerial and hyaline appressed mycelia. After 2 days the character of the mycelium changes to woolly-cottony with patches of sub-felty mat initially near the centre of the plate but later on spreading outwards in a circular manner imparting a faintly zonate character to the mat. In about a week's time by fresh addition of mycelium the mat is transformed into evenly sub-felty type, but retaining the original cottony character along the periphery. After about 10 days the development of fruitbodies takes place, initially round the inoculum, and later on, along the successive rings in a characteristic fashion, the more conspicuous and better developed ones are formed along the margin of the plate.

Basidia clavate, $5 \cdot 5$–$6 \cdot 5\mu$ broad (T. Figs. 9, 10 and 11) ; spores hyaline, thin-walled, fusiform-elliptical, $5 \cdot 6$–$7 \cdot 5 \times 3 \cdot 2\mu$, aver. $6 \cdot 0 \times 2 \cdot 8\mu$ (T. Fig. 12).

On the media the fruitbodies mature and discharge spores in about two weeks. The spores germinate in 8–12 hours giving out apical and lateral germ-tubes, and when transferred

* These numbers refer to Museum specimens in Mycological Branch, Forest Research Institute, Dehra Dun.

in malt agar media they produce vigorous mycelia. The immature fruitbodies develop a tinge of 'pale ochraceous salmon' to 'light ochraceous salmon' and on attaining maturity developed 'salmon buff' colour.

Aerial hyphae nodose, branched, regular with whorled clamp connections (T. Fig. 6) width 1·5–3·0μ ; appressed hyphae hyaline, nodose, branched with whorled clamp connections (T. Fig. 7), width 2·5–4·0μ ; old hyphae uniform, fibrous without lumen, septate and with old clamp connections ; chlamydospores are formed on the appressed hyphae of 7 days old mycelium ; medallion hyphae are found in the wood in the advanced stage of decomposition.

Growth (radial) of the fungus maintained in malt agar medium at 20°–22°C.

24 hours	..	a trace
2 days	..	1 cm.
3 ,,	..	1·5 cms.
4 ,,	..	2·7 ,,
5 ,,	..	3·5 ,,
6 ,,	..	4·0 ,,
1 week	..	4·5 ,,

Covers the plate of 12 cms. in ten days.

Oxidase tests—On gallic acid agar no diffusion zone, growth 3·2 cms. ; on tannic acid agar no diffusion zone, growth 3·5 cms. in 8 days ; on gentian violet agar no discolouration, growth weak.

Loss of weight of wood blocks in agar culture for four months at 25°–26°C.

	Sal sapwood	Sal heartwood	Chir sapwood	Chir heartwood
	%	%	%	%
Max. ..	37·60	29·69	62·5	54·83
Min. ..	7·66	0·26	48·18	32·14
Aver. ..	30·55	10·21	56·98	44·45

Polyporus palustris (Fr.) Mass. = *P. palustris* Berk. and Curt. is described as one of the species of the *Trametes serialis* group. It has been stated to occur in the southern states of U.S.A. but has not been reported from Canada. This fungus has been confused with *T. serialis* because of similarities of fruitbodies and culture (Nobles, 1943).

(*b*) Decay in *Picea* sp. (*P. morinda* probably) due to *Poria* sp. ; M. 754 : Culture No. 157-T.

This is the second specimen of decay collected from the same place as the one described above. The decay was diagnosed by the dull brown colour with patches of lighter shade in the sound wood. In advanced stages oblique cracks appear (Pl. III, Fig. 3) due to shrinkage and the wood becomes soft, friable and finally crumbles into sawdust.

On wood incubated in the moist chamber the fungus emerged as cottony mycelia after 6 weeks, changing to woolly-cottony after about 8 weeks and produced loose sub-felty mat after 6 months (Pl. III, Fig. 4). Later on, shallow pores were formed on the sporophore initials which were soon covered by fresh formation of woolly-cottony hyphae. The seasonal activity of the fungus beginning in May continued up to October from year to year in the same way, the sporophores were formed in July (Pl. III, Fig. 5) but were overgrown by the mycelia in October, till the wood was reduced to a crumbly mass.

PLATE 1

FIG. 1

FIG. 2

PLATE II

FIG. 1

FIG. 2

PLATE III

FIG. 1

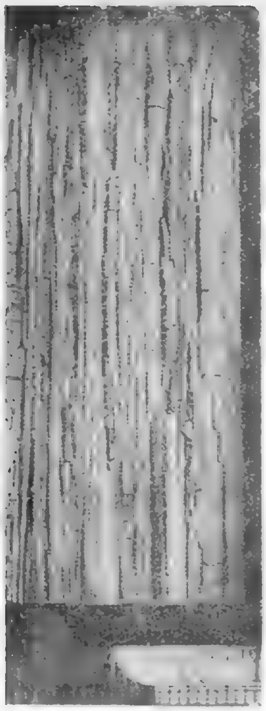


FIG. 2

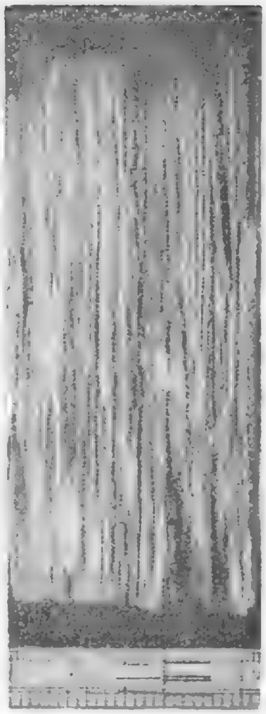


FIG. 3 FIG. 4

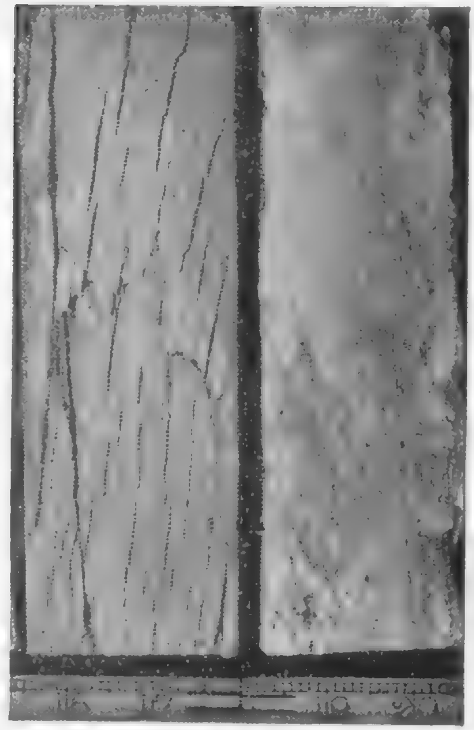
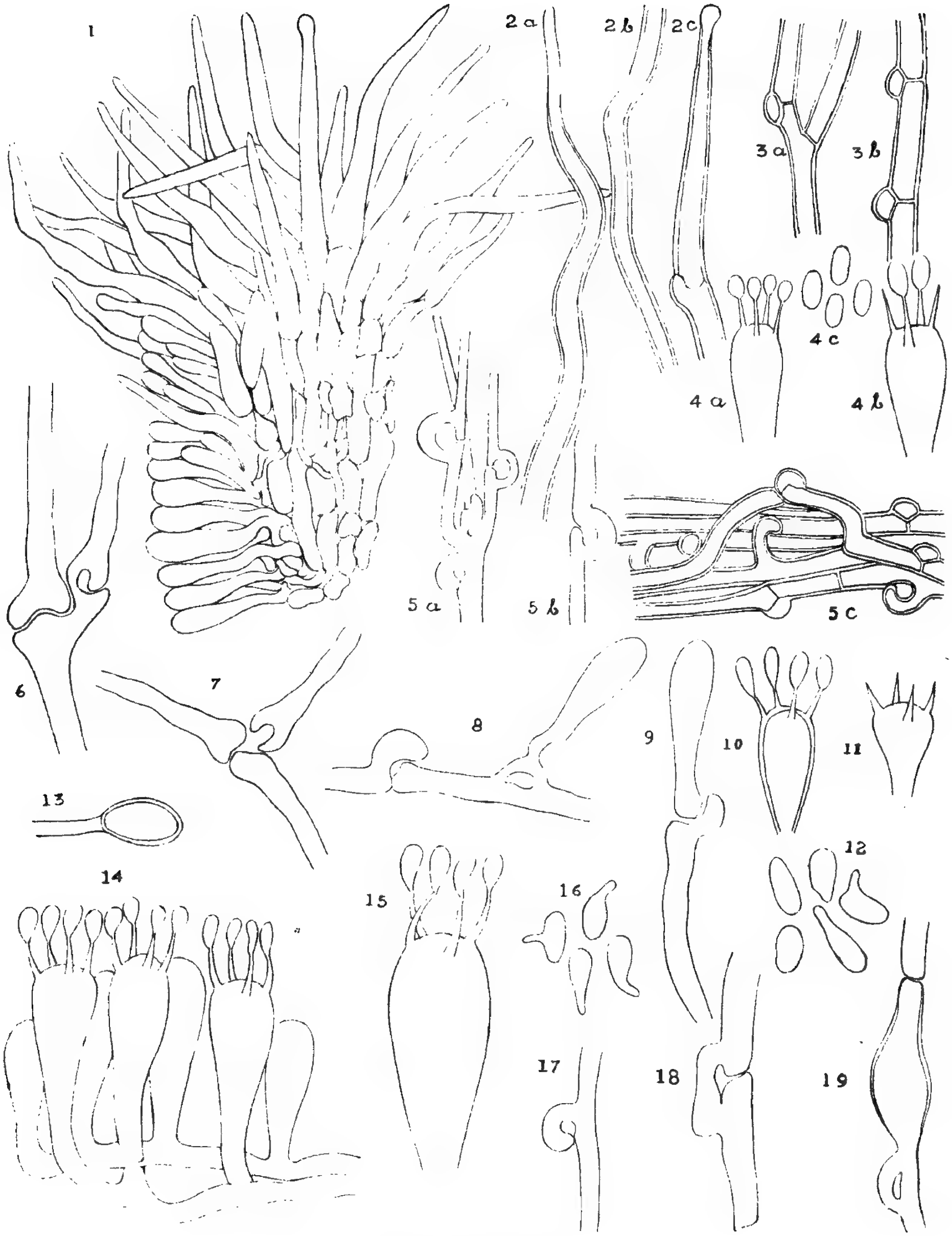


FIG. 5



TEXT FIGURES

Cultural characters—The fungus slowly initiates growth, forming appressed sub-hyaline mycelium on the plate in contact with the initial inoculum 48 hours after transfer. The mycelium assumes a sodden appearance but later on changes to white as it grows during the next two days. Initials of sporophores as a poroid formation appear in about a week in the older region close to the inoculum extending gradually outwards, the advancing zone remaining sodden, appressed and sub-hyaline. The pores are irregular in formation, very shallow but are lined by hymenium containing loosely packed young basidia (T. Fig. 14). The basidia mature (T. Fig. 15) in 10–12 days and discharge spores. The pores are covered by fresh mycelia and become indistinct. The mat in old culture of 4 weeks appears somewhat translucent under the reflected light, the colour changing to 'light buff' and 'pale pinkish buff'. Hyphae short, cottony to appressed, hyaline, branched, both nodose, short-celled, thin-walled (T. Fig. 17), $2{\cdot}0$–$3{\cdot}0\mu$ broad and long-celled, thick-walled (T. Fig. 18), $2{\cdot}0$–$4{\cdot}0\mu$, both types bear clamp connections, the former are transformed into clavate fertile hyphae ending in basidia, the latter ones into small to obliterated lumen fibre hyphae ; basidia (T. Fig. 15) clavate, $14{\cdot}0 \times 6{\cdot}5\mu$; spores (T. Fig. 16) ovoid, $4{\cdot}0 \times 3{\cdot}0\mu$; sterigmata thin ; chlamydospores spindle-shaped (T. Fig. 19).

Growth (radial) of the fungus in neutral malt agar media in darkness at 20°–22°C.

24 hours	.. Nil
2 days	.. a trace
4 ,,	.. 1·5 cms.
8 ,,	.. 3·5 ,,

Oxidase tests—On gallic acid agar, no diffusion zones, growth 1·4 cms. ; on tannic acid agar no diffusion zone, growth 1·4 cms., in 8 days ; on gentian violet agar no discolouration, growth weak.

Loss of weight of wood blocks in agar culture for four months at 25°–26°C.

	Chir sapwood	Chir heartwood
	%	%
Max.	**26·62**	**19·10**
Min.	**10·24**	**10·71**
Aver.	**17·65**	**13·97**

The fungus presenting the above characters appears to be a poroid Basidiomycetes, probably a brown *Poria* of temperate region. It could not be identified although it was examined in four laboratories in U.K., U.S.A. and Canada. Also compared with the cultures of Himalayan *Porias* in the Forest Research Institute it could not be matched, nor could it be fitted in the Key Pattern of *Polypores* issued from other laboratories maintaining wood-decaying fungi.

The colours described in the paper under inverted commas, are based on 'Color Standard and Color Nomencalture' – Ridgway (1912).

The author is thankful to Shri Y. N. Puri, M.Sc., Research Assistant, Mycology Branch, Forest Research Institute for his constant attention and help during the experimental work and isolation of fungi.

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PANELLUS RUPICOLA

Text Figures

FIG. 1.—Section of a sporophore through the hymenium showing hairs, tramel hyphae, generative hyphae and young basidia. × 540.
FIG. 2.—Hairs. × 1225.
FIG. 3.—Tramal hyphae. × 1225.
FIG. 4.—(a) Young basidium, (b) Mature basidium, (c) Basidiospores. × 1225.
FIG. 5.—(a) Aerial hyphae, (b) appressed hyphae, (c), a piece of mycelia from old mat. × 1225.

POLYPORUS PALUSTRIS

Text Figures

FIG. 6.—Aerial hyphae. × 1225.
FIG. 7.—Young appressed hyphae. × 1225.
FIG. 8.—Formation of basidia from appressed hyphae. × 1225.
FIG. 9.—A young basidium. × 1225.
FIG. 10.—A fully developed basidium. × 1225.
FIG. 11.—A collapsed basidium after the spores are discharged. × 1225.
FIG. 12.—Basidiospores. × 1225.
FIG. 13.—A chlamydospore. × 1225.

DRIFT TIMBER II

FIG. 14.—Young basidia from culture. × 1225.
FIG. 15.—A fully developed basidium. × 1225.
FIG. 16.—Basidiospores germinating. × 1225.
FIG. 17.—Thin-walled appressed hyphae. × 1225.
FIG. 18.—Thick-walled appressed hyphae. × 1225.
FIG. 19.—A chlamydospore. × 1225.

EXPLANATION OF PLATES

PLATE I

FIG. 1.—*Panellus rupicola*, sporophores on the bark of a young deodar tree.
FIG. 2.—*P. rupicola* on the bark and sapwood along the edge of the canker from a pole tree of deodar.

PLATE II

FIG. 1.—Sporophores of *P. rupicola* on the decaying stump of deodar, showing the typical habitat.
FIG. 2.—Sporophores of *P. rupicola* on the blocks of chir pine (*P. longifolia*) reproduced after 3 months at 20°-22°C.

PLATE III

FIG. 1.—Rot on *Picea* sp. due to *Polyporus palustris*.
FIG. 2.—Decay with the fungus mycelia of *P. palustris* on the timber after incubation for one year.
FIG. 3.—Rot on *Picea* sp. due to *Poria* sp.
FIG. 4.—Decay with the fungus mycelia of *Poria* sp. after incubation for 6 months.
FIG. 5.—The sporophore of *Poria* sp. and crumbly brown rot on the timber after incubation for three years. × 9.

CONTRIBUTION TO THE FLORA OF THE GIR FOREST IN SAURASHTRA

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SUMMARY

The Gir forest, more popularly known as the only remaining home of the Asiatic lion in India, has an area of about 500 square miles.

The authors who are concerned with the Gir forest vegetation, studied it in the month of October, when it is rich in herbaceous plants and tall grasses. Teak is the main forest tree which, however, except in specially managed areas consists of crooked trees as a result of maltreatment. *Terminalia crenulata* is next in importance and then come *Wrightia tinctoria*, *Dalbergia latifolia* and *Sterculia urens*, whereas the gregarious *Acacia arabica* and *Zizyphus nummularia* constitute the thorny scrub. Grouped near the villages are the Tamarind, the banyan, *Bassia* and ornamental trees such as *Delonix regia* and *Erythrina suberosa*.

Near the Hiran River *Saccharum spontaneum* is conspicuous.

The buffalo population of the Gir is far too much for the available grazing and various regulations have been made to control the numbers. The local shepherds called *Maldaris* are however, a dwindling race due to incidence of diseases and high degree of sterility. Apparently the people best suited for the conditions are some Negroes who came to India a long time ago.

Much attention has recently been given by the forest department to conservation of water by means of small dams, over 5,000 in number, and to planting of useful kinds of trees. New plantations of teak, *Salmalia malabarica* and *Terminalias* are coming up. Such measures together with control on buffalo population should bring about a good forest growth in the Gir.

Appended to the paper is a list of over 400 plant species collected in the area. It is arranged according to the system followed in the Flora of British India and similar works, with the names brought up-to-date as far as possible according to rules of botanical nomenclature. No attempt has been made to give descriptions as these are easily available in standard floras.

Introduction—The Gir Forest in Saurashtra is notable for being the only place in India where the Asiatic lion is still living and in fair numbers. For a full discussion on the question of the Gir lions, see Wynter-Blythe in *Jour. Bombay Nat. Hist. Soc.* 48 : 493–514, 1949 ; and for a census of the number of lions in the same forest, see Wynter-Blythe and Dharma Kumarsinhji in the same journal, 49 : 456–470, 1950. The presence of lions in the forest has operated for the good of the forest ; for the authorities of the State before Independence took pride in the fact that lions were to be found there, and in consequence protected the forest from the usual deforestation which is seen everywhere in Saurashtra. In spite of this protection, however, the forest of recent years has seen a gradual but steady diminution. According to Mr. P. N. Deogun, the Chief Conservator of Forests up to November 1953, in 1900 the area of the Gir forest was about 1,000 square miles ; by 1953 it had shrunk to about 500 sq. miles. At

all events, there is still some forest left in the Gir, and it is left to the patriotic sense of the new generation to see that the forest is properly looked after and that its area does not go down but on the contrary increases to the proper size.

Situation—The Gir forest reserve is situated south of Junagadh at a distance of about 30 miles. Its longest length is 43½ miles and its longest breadth is about 24 miles. On the southern side near Una Mahal the forest is within 15 miles of the sea. It is bounded on the North by Visavadar Mahal, on the East by Baroda territory and Lakhapdar Chovishi, on the South by Una Mahal and on the West by Jetpur territory.

Configuration—The forest area is rugged and broken. The hills are low. The lowest point is 741 feet while the highest point (Vasadhal hill) is 1,741 feet. The slopes are moderate and from South-West to West the hills merge in the plains. The drainage is from North to South and the reserve is split up by water shade from which streams run to all points of compass and feed the six principal rivers, viz., Hiran, Singawada, Machhundri, Jatardi, Godavadi and Rawal. These rivers have a perennial supply of water and it is the abundant supply of water and ample grazing that have made the Gir reserve as the centre of cattle breeding.

Geology—The hills are of volcanic origin and consist of trap, basalt and limestone. The rock is close to the surface and often crops out and the soil is variable in depth and composition from stony reddish white on the upper slopes of the hills to rich black soil in valleys and plains, often of considerable depth. There is no humus on the soil except along the banks of rivers and large water courses.

Climate and Rainfall—The climate is unhealthy during the rainy season, with frequent out breaks of malaria, and in cold weather, but it begins to improve from February ; March to May are the healthiest months. The maximum temperature is 110°F. while the minimum falls as low as 45°F. December to January are the coldest months. Monsoon breaks in the latter part of June and July and August are months receiving greatest precipitation. The average rainfall is 30 inches, Junagadh and Sasan being in close proximity of the forests receive a higher average rainfall while places farther away from the forests, receive less.

Wild animals—Among the wild animals the most famous is the Lion. His favourite food is the *nilgai*, *sambhar*, wild hog and cows, but quite often he kills a stray young buffalo. Panthers and *chitahs* are also found in the Gir but the panthers, as a rule, are said to live in fixed places and do not wander so much as lions. Jackal, wolf and hare are also common, the first two usually on the outskirts of the forest. In addition to the above, wild pig, monkeys, *sambhar*, spotted deer, blue bull (*nilgai*) are also fairly numerous in the Gir. The Indian Badger, called *ghorkhodia* or the corpse digger is said to be not uncommon in the Gir but from its nocturnal habit, is rarely seen.

The Lions of the Gir—Speaking of lions, during the lengthy excursions made in the forest, we heard numerous stories about them, but have been unlucky in that we were unable to see them in day time ; we had a fleeting glance during our second excursion in October 1953. In the first excursion conducted by one of us, our party went out in a jeep in search of lions ; evening time is supposed to be best for the purpose. Our party set out at about 8 P.M. At one of the villages in the forest, we were informed that a couple of lions had been playing or courting just outside the village for several hours that very afternoon and evening, in sight of the inhabitants of the village. We were unlucky, and could not see any lion in that excursion. In our second outing in the forest in October 1953, one night, just before going to bed, we heard a lion just outside our rest-house at Sasangir ; the animal set up a frightening roar not far from the village. We went out in the company of several foresters, and followed the

Negro children from a colony at Shirwan Ness.

Photo by : H. Santapau.

A family of one of the Maldaris or *Shepherds*.

Photo by : H. Santapau.

A corner of dense forest along one of the streams in the Gir.

Photo by : H. Santapau.

View of Hiran River near Sasan. The White Patches in river are *Saccharum spontaneum* Linn.

Photo by : H. Santapau.

From a Kodachrome

H. Santapau, S.J.

GIR FOREST
near Junwania Nes

[This coloured plate was supplied by the authors]

animal. Lions are said to have very soft pads on the underside of their feet and for this reason cannot stand rough ground, much less the thorns of *Acacia arabica*. The animal marched along the clear road ; we followed and on several occasions could see it marching in front of us, along the road, until we lost sight of it in the neighbourhood of the river. The foresters informed us that there was no danger for us in following the lion, since lions generally leave humans alone, unless the latter molest them when they are at their kill.

First Impressions of the Gir Forest—The first impressions as one enters the Gir district are very good ; the roads in October are generally in a very poor condition after the torrential rains of the monsoon have washed away the surface and produced a number of ruts and holes ; this means that cars have to travel slowly and with very great care, but this for a botanist is a blessing, since then he can have a good look at the country all along the route. On either side of the road the vegetation is rich in herbaceous plants, and at the beginning of October, *Barleria prattensis* Sant. is one of the most common and showy plants by the road side. The open parts of the forest, where trees are not abundant enough to shade the undergrowth out of existence, are covered with a dense growth of various grasses, up to 6 feet tall ; such grasses make a very pleasant sight after the barrenness of the rest of the country.

The main constituent of the forest proper is *Tectona grandis* ; but the trees are seldom over 25 feet high, and their trunks are crooked and often hollow, the result of bad treatment in the past. In certain spots, where the Forest Department under the energetic direction of Mr. P. N. Deogun has been concentrating attention in the last few years, one can see fine specimens of *Tectona*, small trees as yet, but straight and without unsightly wounds. *Terminalia crenulata* is also common and reaches quite a good size ; *Wrightia tinctoria* and *Dalbergia latifolia* are widespread all over the Gir, but the trees again are rather poor in size and shape. In the neighbourhood of human habitation we saw some specimens of *Tamarindus indica,* about the largest trees in the district, except for a few large groups of *Ficus benghalensis*, the banyan tree, which are by far the largest trees in the Gir. *Salmalia malabarica* is generally rare, but in the last few years over two hundred thousand trees have been planted in various parts of the forest and seem to be thriving. *Sterculia urens* is by far the most conspicuous tree in open places, where the tree growth is not too dense ; with its whitish bark the trees stand out against the generally brown or dark green background of the forest. Scattered everywhere and in places in great concentration, one sees *Acacia arabica* and a few other species of *Acacia,* together with *Zizyphus mauritiana, Z. nummularia*, etc. ; this is particularly the case in the neighbourhood of the various *nesses* of shepherds' huts in the forest ; buffaloes do untold damage to the trees, especially to the young ones by rubbing against them ; the thorns of the *Acacias* and *Zizyphus* safeguard the trees against the buffaloes.

To give a more detailed account of the forest as we saw it, a few extracts from one of our diaries are herewith appended.

> "*5 Oct. 1953*—Junwania Nes. Went by truck with some forest officers, who showed us the way. Teak is rather dense all along ; *Zizyphus mauritiana* and *Z. oenoplia* abundant along the roads in open forest ; *Z. nummularia* common. Outstanding is the abundance of *Barleria prattensis* in full bloom in the undergrowth, particularly near the road, probably the most abundant single species in showy bloom. To-day found *Nervilia,* the first orchid seen in the Gir so far ; the plant was found in masses on sloping moist earth banks, but the plants were only in leaf ; tubers were collected for further study and cultivation. The forest roads are good. The undergrowth is made up of *Barleria prattensis, Cassia tora, Triumfetta bartramia*, several species of *Hibiscus, Blepharis*, etc. We crossed several streams with plenty of water in them. Near Junwania Nes there are some two or three large clumps of *Ficus benghalensis,*

the largest trees seen to-day. In the middle of the streams *Ceratopteris thalictroides* is very abundant; on rocks *Rotala tenuis* forms large patches. The people of the Nes are dying out, due to low birth rate combined with high infantile mortality, the cause is said to be principally dirty water. The loss of buffaloes is very high due to lions; the owner of the stables at Junwania Nes informed us that in about a year he has lost about 200 buffaloes. In the evening after pressing the morning's collection went to the river Hiran, where we saw a plant that looks remarkably like *Pristimera grahamii* (Note: by anatomical study it was later found that the plant was *Combretum ovalifolium*). . . . . ".

"*6 Oct. 1953*—Went to the river Hiran, through the Forest Nursery and higher up along the stream. *Combretum* is one of the most abundant plants on the sides of the river. *Barleria prattensis* was also abundant in the forest near the Nursery. On hedges collected *Oxystelma esculentum* near water. Return through the forest, not along the river; on paths found *Crotalaria orixensis, Striga euphrasioides*, etc.".

"*7 Oct. 1953*—Went to the river sides, down stream, south of the main dam. On shady cool spots our guards told us to keep an eye for lions, as the spot is known to be the most frequented haunt of these animals especially during the dry season. In the forest near the river, the predominant tree is teak; many babul trees, *Zizyphus, Combretum*, etc., in the undergrowth *Impatiens acaulis, Barleria prionitis* and *B. prattensis, Triumfetta bartramia, Hibiscus* with small white flowers, *Triumfetta rotundifolia*. Along the river banks we saw an *Eugenia* with narrow leaves, good sized trees in leaf only; *Pongamia pinnata, Ficus bengalensis* are striking for their size and numbers; birds are very rare here".

"*8 Oct. 1953*—Went to the highest point in the district, a hill due north of Sasangir, a little over 1,000 feet high. The going was made difficult because of the high grasses on the path and slopes; on the slopes saw *Soymida febrifuga, Odina, Wrightia tinctoria, Sterculia urens*, etc. On top of the hill collected *Tricholepis asperrima, Lavandula* and a very tall *Ischaemum*. The view from the top is grand: rather dense forest for miles around the hill; any clear spaces taken up by grasses; the country is saucer-shaped, with the hill practically in the centre, the edges or rim of the saucer densely wooded; the river Hiran passes through the middle. On the return journey met a *sambhar*, and saw many pug marks of lion in the forest paths . . . . ".

"*9 Oct. 1953*—Last evening went for a walk along the main Sasan road, passing near the station; in the outskirts of the village saw *Bassia, Moringa, Delonix regia, Ehretia laevis*; in the forest collected *Erythrina suberosa* in leaf, and the only specimen of *Loranthus* seen in the Gir. At 11 A.M. this morning took the train for Junagadh; the aspect of the forest along the line is good; but as soon as we came to the Revenue Areas the look of the country changed completely; large patches of cultivated ground with *Arachis, Pennisetum*, etc., there".

The Vegetation in and near Hiran River—The river Hiran passes a short distance from Sasangir; all over the most conspicuous plant is *Saccharum spontaneum* in flower and fruit, a grand sight. On the sides of the river *Combretum ovalifolium* is typical, with stems ever 6 inches in diameter and climbing to great heights. In the middle of the river, and in other streams in the forest we collected large numbers of water plants; *Ammannia*; *Ludwigia parviflora*, and several species of *Cyperaceae*, which we have not yet identified; on moist shaded spots *Ipomoea calycina* is one of the commonest plants. When one of us went into

the Gir the previous year, one of the commonest plants was *Mitreola oldenlandioides* ; this time the plant was occasionally seen but not in the profusion of the previous visit.

The Gir buffaloes—One word must be said about the buffaloes and the damage they cause in the forest. One of us heard the Minister in charge of Forests say that the Gir could well support up to 5,000 buffaloes. Various regulations have been made to control their numbers, but up to the present with little effect. In October 1953, the number of buffaloes in the Gir was estimated at over 50,000, that is to say ten times more than the forest can support. The State charges a small fee for each animal kept in the forest ; but local shepherds ignore such regulations and allow their animals to multiply to excessive numbers. When a spot is assigned to the shepherds for buffalo grazing, gradually the spot loses its trees, with the exception of spiny useless ones ; when a spot becomes unprofitable, shepherds move their animals further into the Gir, and the devastation gradually spreads in the forest. When in addition and contrary to all regulations shepherds keep a few goats, the ruin of the forest becomes complete. Little by little *Acacia arabica* and various species of *Zizyphus* take over from teak and other useful trees, and by then the forest has become a wilderness. The first intimation one gets of the approach to one of the Nesses is that teak has disappeared from the forest and spiny shrubs or small trees come to form the dominant type of vegetation.

Financially buffaloes are not a very good proposition for the State ; *ghee* is prepared from milk, and this is exported to various parts in western India ; butter, cheese and other milk products seem to have no sale, and in consequence are not prepared. This is a rather wasteful method of utilizing buffalo milk, but so far no alternative has been offered to the local herdsmen.

On several occasions we heard that the race of *Maldaris* or Gir shepherds is dying out ; two reasons are given for this : there is a high degree of sterility among the *Maldaris*, and in addition child mortality is also high. Some forest officers attribute both troubles to the impurities in drinking water, which is not treated in any way for human consumption ; other officers are inclined to attribute both troubles to deficiency diseases. Be that as it may, there is no doubt that one sees very few children among the Gir *Maldaris*, and this augurs badly for the continuance of the race. Apparently the best suited people for the conditions prevalent in the Gir are some Negroes who came to India a long time ago, and have settled in some far away corners of the forest ; they seem to compete very successfully with local conditions, if we are to judge from the number of children one sees in such Negro settlements in the Gir.

The Regeneration of the Forest in the Gir—During the tenure of office of Mr. P. N. Deogun as Chief Conservator of Forests of Saurashtra, much attention has been paid to the solution of two problems : the conservation of water in the forest, and the replanting of useful trees. The first problem has in part been solved by the construction of large numbers of small dams all along the streams in the forest. This has already resulted in the retention of very good forest soil near the dams, soil that previously used to be carried away to the sea. In addition numerous pools have been formed all along the streams, where water is found practically throughout the year except in the very hot month just before the monsoon. During our last outing in the Gir, we understood that over 5,000 such small dams have been constructed in the Gir. As a consequence of the presence of water in the forest, wild life is not forced to move out of the forest during the greater part of the year. In the moist soil near the small dams we found abundant plant life ; herbs that only grow in water or on very moist soil are abundant there during most of the year ; the trees nearby show also the effect of this moisture in the atmosphere. Such dams have been erected at very moderate cost, and are now already repaying the amounts spent in their construction.

On the problem of the reforestation of the Gir, we have had ample opportunity for seeing the new plantations ; *Salmalia malabarica*, *Tectona grandis*, several species of *Terminalia*, and many other useful trees have been planted, and so far seem to be thriving. Provided such trees are carefully looked after for some time, there is ample promise that the whole aspect of the forest will change in a few years, and that the forest will become one of the best financial assets of the State ; this promise will only be realized if the buffaloes are kept under proper control, and are not allowed to destroy what the Forest Department has with such labour built up in the course of a few years.

List of Plants of the Gir Forest—The following list is primarily compiled from the results of our joint excursion during October 1953 ; obviously it would be presumptuous on our part to claim that it is a complete one, since the time spent in the district was barely one week. In order to complete the list, we have drawn upon the results of two previous expeditions both made during October 1952 ; the first was undertaken by the senior author of this paper, and lasted for just over a week ; the second was carried out by Prof. P. V. Bole, who paid particular attention to the grasses of the Gir. Even so, all we can claim for this list is that it represents the more obvious and common plants of the district, and in this respect we are of opinion that it is worth publishing as a contribution to our knowledge of the flora of the Gir.

Plants are given in this list in the same order as they were shown in the senior author's *Plants of Saurashtra.—A Preliminary List* (1953) ; the order is the same as in Cooke's *Flora of the Presidency of Bombay* or in Hooker's *Flora of British India*. Since the present list does not give any description, we would refer our readers to either book for a complete description. The changes in nomenclature have been explained where necessary in *Plants of Saurashtra*, and therefore such explanations are omitted here.

Before concluding, it is our duty to express our sincere gratitude to the many good friends who helped us during these visits in the Gir ; to Mr. P. N. Deogun, who made all the arrangements for our tour ; to Mr. N. H. Pandya, the D.F.O., Sasangir, who was our host during our stay in the forest, and rendered constant services during our second tour ; to Mr. P. G. Joshipura, R.F.O. who accompanied us during the tour ; and showed us some of the best spots in the Gir ; and finally to a large number of forest officers who very kindly guided us through the complicated paths in the Gir forest. Without their co-operation our tour would not have been possible. To all of them we dedicate this contribution to the Flora of the Gir Forest.

MENISPERMACEAE

Cissampelos pareira Linn.
Cocculus pendulus (Forst.) Diels.
Cocculus hirsutus (Linn.) Diels.

PAPAVERACEAE

Argemone mexicana Linn.

CRUCIFERAE

Brassica nigra (Linn.) Koch.
Brassica oleracea Linn.

CAPPARIDACEAE

Capparis sepiaria Linn.
Cleome viscosa Linn.
Gynandropsis gynandra (Linn.) Briq.

FLACOURTIACEAE

Flacourtia sp.

POLYGALACEAE

Polygala chinensis Linn.
Polygala erioptera DC.
Polygala persicariaefolia DC.

PORTULACACEAE

Portulaca oleracea Linn.
Portulaca quadrifida Linn.

ELATINACEAE

Bergia ammannioides Roxb.

MALVACEAE

Abelmoschus esculentus Moench.
Abelmoschus manihot (Linn.) Medik.
Abelmoschus moschatus Linn.
Abutilon glaucum (Cav.) Sweet.
Abutilon indicum G. Don.
Gossypium sp.
Hibiscus cannabinus Linn.
Hibiscus ficulneus Linn.
Hibiscus rosa-sinensis Linn.
Hibiscus sabdariffa Linn.
Hibiscus solandra L'Herit.
Hibiscus vitifolius Linn.
Kydia calycina Roxb.
Sida acuta Burm.
Sida spinosa Linn.
Sida veronicaefolia Lamk.
Thespesia lampas (Cav.) Dalz. and Gibs.
Urena lobata Linn.

BOMBACACEAE

Salmalia malabarica (DC.) Sch. and Endl.

STERCULIACEAE

Helicteres isora Linn.
Sterculia urens Roxb.

TILIACEAE

Corchorus aestuans Linn.
Corchorus olitorius Linn.
Corchorus trilocularis Linn.
Grewia tiliaefolia Vahl.
Triumfetta bartramia Linn.
Triumfetta rotundifolia Lamk.

BALSAMINACEAE

Impatiens acaulis Arn.
Impatiens balsamina Linn.

GERANIACEAE

Biophytum sensitivum (Linn.) DC.

RUTACEAE

Aegle marmelos Corr.
Citrus medica var. *limonum* Hook.
Murraya koenigii Spr.

SIMARUBACEAE

Ailanthus excelsa Roxb.
Balanites roxburghii Planch.

BURSERACEAE

Boswellia serrata Roxb.
Garuga pinnata Roxb.

MELIACEAE

Azadirachta indica Juss.
Melia azaderach Linn.
Soymida febrifuga Juss.

CELASTRACEAE

Celastrus paniculata Willd.

RHAMNACEAE

Zizyphus mauritiana Lamk.
(*Z. jujuba* Lamk. 1789, non Mill. 1768).
Zizyphus nummularia (Burm.) Wt. and Arn.
Zizyphus oenoplia (Linn.) Mill.
Zizyphus glabrata Heyne ex Roth.
(*Z. trinervia* Roxb., non Poir.)
Zizyphus xylopyrus Willd.

VITACEAE

Ampelocissus latifolia (Roxb.) Planch.
Cayratia auriculata (DC.) Gamble.
Cayratia carnosa Gagnep.
Cissus repanda Vahl.

SAPINDACEAE

Cardiospermum halicacabum Linn.
Sapindus trifoliatus Linn.

ANACARDIACEAE

Lannea grandis (Dennst.) Engl.
Mangifera indica Linn.

MORINGACEAE

Moringa oleifera Lamk.

PAPILIONACEAE

Abrus precatorius Linn.
Aeschynomene indica Linn.
Alysicarpus hamosus Edgw.
Alysicarpus longifolius (Rottl.) Wt. and Arn.
Alysicarpus rugosus (Willd.) DC.
Alysicarpus tetragonolobus Edgw.
Alysicarpus vaginalis (Linn.) DC.
Atylosia platycarpa Benth.
Butea monosperma O.K.
Butea superba Roxb.
Canavalia gladiata (Jacq.) DC.
Clitoria biflora Dalz.
Clitoria ternatea Linn.
Crotalaria filipes var. *trichophora* Cooke.
Crotalaria juncea Linn.
Crotalaria leptostachya Benth.
Crotalaria linifolia Linn. f.
Crotalaria medicaginea Lamk.
Crotalaria orixensis Wt. and Arn.
Crotalaria prostrata Roxb.
Dalbergia latifolia Roxb.
Dalbergia sissoo Roxb.
Desmodium diffusum (Willd.) DC.
Desmodium gangeticum (Linn.) DC.
Desmodium laxiflorum DC.
Desmodium rotundifolium Baker.
Desmodium triflorum (Linn.) DC.
Erythrina suberosa Roxb.
Heylandia latebrosa (Linn.) DC.
Indigofera cordifolia Heyne.
Indigofera glandulosa Willd.
Indigofera hirsuta Linn.
Indigofera linifolia Retz.
Indigofera tenuifolia Rottl.
Indigofera trita Linn. f.

(*contd.*)

PAPILIONACEAE—(*concld.*)

Mucuna prurita Hook. f.
Phaseolus radiatus Linn.
Pongamia pinnata (Linn.) Pierre.
Pseudarthria viscida (Linn.) Wt. and Arn.
Psoralea corylifolia Linn.
Pueraria thunbergiana Benth.
Pueraria tuberosa (Roxb.) DC.
Rhynchosia bracteata Benth.
Rhynchosia minima (Linn.) DC.
Rhynchosia sericea Spanoghe.
Sesbania bispinosa (Jacq.) Fawcett and Rendle.
Sesbania bispinosa var. *cannabina* Sant.
Smithia conferta var. *geminiflora* Cooke.
Smithia sensitiva Air.
Tephrosia purpurea Pers.
Tephrosia villosa Pers.
Teramnus labialis Spr.
Zornia diphylla Pers.

CAESALPINIACEAE

Bauhinia purpurea Linn.
Bauhinia racemosa Lamk.
Cassia absus Linn.
Cassia auriculata Linn.
Cassia fistula Linn.
Cassia glauca Lamk.
Cassia occidentalis Linn.
Cassia pumila Lamk.
Cassia siamea Lamk.
Cassia tora Linn.
Tamarindus indica Linn.

MIMOSACEAE

Acacia arabica (Lamk.) Willd.
Acacia ferruginea DC.
Acacia leucophlaea Willd.
Albizzia lebbeck (Linn.) Benth.
Dichrostachys cinerea (Linn.) Wt. and Arn.
Leucaena glauca (Linn.) Benth.
Mimosa hamata Willd.
Prosopis juliflora DC.
Samanea saman (Jacq.) Merr.

HALORAGIDACEAE

Myriophyllum sp.

COMBRETACEAE

Anogeissus latifolia (Roxb.) Wall.
Combretum ovalifolium Roxb.
Terminalia bellerica (Gaertn.) Roxb.
Terminalia chebula Retz.
Terminalia crenulata Roth.

MYRTACEAE

Syzygium cumini (Linn.) Skeels ?

LYTHRACEAE

Ammannia baccifera Linn.
Ammannia multiflora Roxb.
Lawsonia inermis Linn.
Rotala tenuis Koehne.
Woodfordia fruticosa (Linn.) Kurz.

FICOIDEAE

Glinus lotoides Linn.
Mollugo pentaphylla Linn.
Trianthema decandra Linn.

ONAGRACEAE

Ludwigia parviflora Roxb.

CARICACEAE

Carica papaya Linn.

PASSIFLORACEAE

Passiflora edulis Sims.

CUCURBITACEAE

Bryonopsis laciniosa (Linn.) Naud.
Coccinia indica Wt. and Arn.
Cucumis callosus (Rottl.) Cogn.
Luffa acutangula var. *amara* Clarke.
Luffa echinata Roxb.
Melothria maderaspatana (Linn.) Cogn.
Trichosanthes bracteata (Lamk.) Voigt.
Trichosanthes cucumerina Linn.

ALANGIACEAE

Alangium salvifolium (Linn. f.) Wang.

RUBIACEAE

Adina cordifolia (Roxb.) Hook.
Borreria stricta (Linn. f.) Schum.
Ixora brachiata Roxb.
Meyna laxiflora Rob.
Mitragyna parvifolia (Roxb.) Korth.
Morinda tinctoria var. *tomentosa* Hook. f.
Randia brandisii Gamble.

COMPOSITAE

Acanthospermum hispidum DC.
Ageratum conyzoides Linn.
Bidens biternata (Lour.) Merr. and Sherf.
Blainvillea latifolia (Linn. f.) DC.
Blumea glomerata DC.
Blumea mollis (D. Don) Merrill.
Cyathocline purpurea (Don) O.K.
Echinops echinatus Roxb.
Eclipta alba (Linn.) Hasskarl.
Emilia sonchifolia (Linn.) DC.
Goniocaulon glabrum Cass.
Helianthus annuus Linn.
Lagascea mollis Cav.
Launaea chondrilloides Hook. f.
Pluchea lanceolata Clarke.
Pulicaria angustifolia DC.
Pulicaria wightiana (DC) Benth. ex Clarke.
Sclerocarpus africanus Jacq.
Sphaeranthus indicus Linn.
Tricholepis glaberrima DC.
Tridax procumbens Linn.
Vernonia anthelmintica (Linn.) Willd.
Vernonia cinerea (Linn.) Less.
Vicoa indica (Willd.) DC.
Volutarella ramosa (Roxb.) Santapau.
Xanthium strumarium Linn.

PLUMBAGINACEAE

Plumbago zeylanica Linn.

SAPOTACEAE

Madhuca indica Gmel.
Manilkara hexandra (Roxb.) Dub.

EBENACEAE

Diospyros melanoxylon Roxb.

OLEACEAE

Jasminum pubescens Willd.
Schrebera swietinoides Roxb.

APOCYNACEAE

Carissa congesta Wt.
Nerium indicum Mill.
Vinca rosea Linn.
Wrightia tinctoria R. Br.

ASCLEPIADACEAE

Calotropis gigantea (Linn.) R. Br.
Cosmostigma racemosum Wt.
Hemidesmus indicus (Willd.) R. Br.
Leptadenia reticulata Wt. and Arn.
Oxystelma esculentum (Linn.) R. Br.
Pergularia daemia (Forsk.) Blatt. and McC.

LOGANIACEAE

Mitreola oldenlandioides Wall.

GENTIANACEAE

Canscora diffusa R. Br.
Enicostema littorale Blume.
Exacum pedunculatum Linn.
Hoppea dichotoma Willd.

BORAGINACEAE

Cordia dichotoma Forst. f.
Cordia rothii R. and S.
Ehretia laevis Roxb.
Trichodesma indicum R. Br.

CONVOLVULACEAE

Argyreia sericea Dalz.
Convolvulus microphyllus Sieb.
Evolvulus alsinoides Linn.
Ipomoea calycina (Chois.) Clarke.
Ipomoea carnea Jacq.
Ipomoea muricata (Linn.) Jacq.
Ipomoea nil (Linn.) Roth.
Ipomoea pes-tigridis Linn.
Ipomoea pilosa Sweet.
Merremia aegyptia (Linn.) Urban.
Merremia chryseides Hall.
Merremia emarginata (Burm. f.) Hall.
Merremia rhynchoriza Dalz.
Operculina turpethum (Linn.) Silva.
Rivea hypocrateriformis Chois.
Hewettia bicolor Wt. and Arn.

SOLANACEAE

Capsicum annuum Linn.
Datura metel Linn.
Datura innoxia Mill.
Lycopersicum esculentum Mill.
Physalis minima Linn.
Physalis peruviana Linn.
Solanum incanum Linn.
Solanum melongena Linn.
Solanum nigrum Linn.
Solanum xanthocarpum Schrad. and Wendl.

SCROPHULARIACEAE

Bramia monnieri (Linn.) Pennell.
Kickxia ramosissima (Wall.) Janchen.
Limnophila indica (Linn.) Druce.
Lindenbergia indica (Linn.) O. K.
Lindernia crustacea Linn. F. Mueller.
Lindernia parviflora (Roxb.) Haines.
Striga euphrasioides (Vahl.) Benth.

MARTINIACEAE

Martinia annua Linn.

PEDALIACEAE

Sesamum indicum Linn.

ACANTHACEAE

Andrographis echioides (Linn.) Nees.
Barleria prattensis Santapau.
Barleria prionitis Linn.
Blepharis maderaspatensis (Linn.) Roth.
Blepharis molluginifolia Pers.
Dicliptera micranthes Nees.
Dipteracanthus patulus (Jacq.) Nees.
Eranthemum purpurascens Nees.
Haplanthus tentaculatus Nees.
Haplanthus verticillatus (Roxb.) Nees.
Hemigraphis latebrosa Nees.
Hygrophila salicifolia Nees. ?
Justicia simplex Don.
Lepidagathis cuspidata (Wall.) Nees.
Lepidagathis trinervis Wall.
Neuracanthus sphaerostachyus (Nees.) Dalz.
Peristrophe bicalyculata (Retz.) Nees.
Rungia parviflora Nees.
Rungia pectinata (Linn.) Nees.

VERBENACEAE

Clerodendrum phlomidis Linn. f.
Gmelina arborea Roxb.
Phyla nodiflora (Linn.) Greene.
Tectona grandis Linn. f.

LABIATAE

Anisomeles indica (Linn.) O. K.
Lavandula bipinnata var. *rothiana* O. K.
Leucas aspera Spr.
Leucas cephalotes Spr.
Leucas zeylanica R. Br.
Ocimum americanum Linn.
Ocimum basilicum Linn.

NYCTAGINACEAE

Boerhaavia repanda Willd.
Bougainvillea spectabilis Willd.

AMARANTACEAE

Achyranthes aspera Linn.
Aerva javanica Juss.
Aerva sanguinolenta (Linn.) Blume.
Amaranthus gracilis Desf.
Amaranthus spinosus Linn.
Amaranthus tricolor Linn.
Celosia argentea Linn.
Digera muricata (Linn.) Mart.
Nothosaerva brachiata (Linn.) Wt.
Pupalia lappacea (Linn.) Juss.

LORANTHACEAE

Dendrophthoe falcata (Linn. f.) Etting.

EUPHORBIACEAE

Acalypha ciliata Forsk.
Acalypha indica Linn.
Acalypha malabarica Muell.-Arg.
Bridelia retusa Spr.
Emblica officinalis Gaertn.
Euphorbia geniculata Ort.
Euphorbia hirta Linn.
Euphorbia hypericifolia var. *parviflora* Hook. f.
Euphorbia microphylla Heyne.
Euphorbia neriifolia Linn.
Euphorbia nivulia Buch.-Ham.
Euphorbia prostrata Ait.
Euphorbia thymifolia Linn.
Euphorbia tirucalli Linn.
Kirganelia reticulata (Poir.) Baill.
Pedilanthus tithymaloides (Linn.) Poir.
Phyllanthus niruri Linn.
Ricinus communis Linn.
Securinega leucopyrus (Willd.) Muell.

MORACEAE

Ficus benghalensis Linn.
Ficus glomerata Roxb.
Ficus hispida Linn.
Ficus religiosa Linn.
Morus alba Linn.

ULMACEAE

Holoptelea integrifolia (Roxb.) Planch.

URTICACEAE

Fleurya interrupta (Linn.) Gaud.
Pouzolzia zeylanica (Linn.) Benn.

CANNABINACEAE

Cannabis sativa Linn.

CASUARINACEAE

Casuarina equisetifolia Linn.

HYDROCHARITACEAE

Ottelia alismoides (Linn.) Pers.

ORCHIDACEAE

Nervilia sp.

ZINGIBERACEAE

Curcuma inodora Blatt.
Musa paradisiaca Linn.

HYPOXIDACEAE

Curculigo orchioides Gaertn.

AGAVEACEAE

Agave sp.

DIOSCOREACEAE

Dioscorea bulbifera Linn.
Dioscorea hispida Dennst.
Dioscorea pentaphylla Linn.

LILIACEAE

Asparagus racemosus var. *javanica* Baker.
Urginea indica (Roxb.) Kunth.

COMMELINACEAE

Commelina benghalensis Linn.
Commelina forskalii Vahl.
Commelina nudiflora Linn.
Commelina obliqua Buch.-Ham.
Cyanotis cristata R. and S.
Cyanotis fasciculata Schult.

PALMAE

Phoenix sylvestris (Linn.) Roxb.

ARACEAE

Colocasia esculenta (Linn.) Schott.

NAIADACEAE

Naias minor All.
Potamogeton sp.

ERIOCAULACEAE

Eriocaulon sp.

CYPERACEAE

Cyperus difformis Linn.
Cyperus eleusinoides Kunth.
Cyperus iria Linn.
Cyperus tagetum Roxb.
Fimbristylis dichotoma (Linn.) Vahl.
Fimbristylis quinqueangularis Kunth.
Heleocharis sp.
Scirpus littoralis Schrad.

GRAMINEAE

Alloteropsis cimicina Stapf.
Apluda aristata Linn.
Aristida adscensionis Linn.
Arundinella pumila (Hochst.) Steud.
Brachiaria ramosa Stapf.
Brachiaria reptans (Linn.) Gard. et Hubb.
Capillipedium hugelii (Hack.) Camus.
*Chloris dol icostachya*Lagasca.
Chloris montana Roxb.
Chloris virgata Sw.
Coix lachryma-jobi Linn.
Cymbopogon martinii (Roxb.) Wats.
Dactyloctenium aegyptium (Linn.) Beauv.
Dendrocalamus strictus Nees.
Dichanthium annulatum (Forsk.) Stapf.
Digitaria adscendens (H.B.K.) Henrard.
Digitaria microbachne (Presl.) Henrard.
Dimeria ornithopoda Trin.
Dinebra retroflexa (Vahl.) Panz.
Echinochloa colonum (Linn.) Link.
Eleusine indica (Linn.) Gaertn.
Eragrostis ciliaris (Linn.) Link.
Eragrostis japonica Trin.
Eragrostis pilosa (Linn.) Beauv.
Eragrostis tenella R. and S.
Eragrostis viscosa (Retz.) Trin.
Hackelochloa granularis (Linn. f.) O. Kuntze.
Heteropogon contortus (Linn.) Beauv.
Isachne australis R. Br.
Isachne dispar Trin.
Isachne travancorense Stapf ex Fischer ?
Ischaemum molle Hook. f.
Melanocenchrus jacquemontii Jaub. and Spach.
Oplismenus burmanii Beauv.
Oryza sativa Linn.
Paspalidium flavidum (Retz.) A. Camus.
Paspalidium gemiminatum (Forst.) Stapf.
Phragmites karka Trin.
Rottboellia exaltata Linn. f.
Saccharum officinarum Linn.
Saccharum spontaneum Linn.
Setaria tomentosa (Roxb.) Kunth.
Setaria verticillata Beauv.
Sorghum vulgare Pers.
Spodiopogon albidus Benth.
Spodiopogon rhizophorus (Steud.) Pilger.
Sporobolus marginatus Hochst.
Themeda triandra Forsk.
Themeda quadrivalvis O. ktze.
Urochloa panicoides Beauv.

FILICES

Adiantum lunulatum Burm.
Ceratopteris thalictroides Brong.

HOPEA PARVIFLORA BEDD., ITS SILVICULTURE AND MANAGEMENT

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English name—Ironwood of Malabar.

Local names—Kanarese—*kiralbhogi, bovumara*; Malayalam—*thambugan, uripu, irumbogam, kambagam, kangu, irubogam*; Tirunalvely—*nirkongu* (*white kongu*); Tamil—*kongu, konju, vellaikongu, irubogam, agil, karankongu, irumbogam*; Coorg—*iruppu*.

Trade name—Hopea.

Description—A large evergreen tree with generally a long, straight, cylindrical bole, reaching a height of 100 feet or more and a maximum girth of 15 to 18 feet or, exceptionally, more. Clean boles of 50 to 60 feet are fairly common when the tree is found mixed with evergreen tall trees but when growing nearly pure on comparatively open laterite soil the boles are more branchy. Bark is light brown or greyish, mottled with white markings in old trees, but rusty brown in young ones. Its surface is smooth with narrow longitudinal cracks in young trees but somewhat rough and exfoliating in older ones. The crown is typically cone shaped in youth so much so that a pole crop seen from a distance on a hill-side looks not unlike a conifer forest (Fig. 1). The shape of the crown of young trees has often been compared to that of a south Indian temple car. Later in life the crown becomes more rounded and dense.

Branchlets reddish-brown, slightly glaucescent. *Leaves*: blade $3\frac{1}{2}$ by $1\frac{1}{8}$ inches, cordate or sub-cordate at the base, glabrous above and paler beneath, at times obtuse, margin undulated, shape ovate apiculate or bluntly acuminate, midrib strong and rather tomentose beneath; lateral nerves prominent below, 6 to 12 pairs (15 pairs: Brandis), with axillary glandular dots at their junction with the midrib; petioles 0·6 inch long, grooved above (S. S. Dhareshwar). *Flower*: buds about $\frac{1}{3}$ inch, tomentose, very shortly pedicelled, *calyx*: segments lanceolate, obtuse, tips of petals dilated and crisped, anthers sub-orbicular, appendage half as long again. (Hooker, I, 309).

Distribution and habitat—The tree is found in the forests of Western Ghats from Honavar range in North Kanara district of Bombay southwards through the ghats and forehill forests of Mysore, Coorg and Malabar to Travancore-Cochin. It also extends to the Tirunalvely district of Madras (Fig. 2). In Honavar range it was discovered by S. S. Dhareshwar in 1940 in the upper valley of the Sharavati River above the famous Gersoppa falls, near Mysore frontier. In Mysore State it is confined to a few selected localities in the revenue districts Shimoga and Chikkamagalur but is found scattered in the evergreen forests of Hassan district. In Jog state forest in the north-west of the State a few trees are found on the banks of Sharavati River in continuation of those found in Honavar range of Bombay State. The tree is then almost absent as far south as Holapur village in Hosanagar range where a magnificent patch of it is found on either bank of Chakra River. Thence, with scattered growth here and there, it spreads into the Varahi and Manibyle forests of Sagar division where it was once fairly abundant. It then enters the Agumbe forest along the source of the Varahi River and continues down to Balehalli state forest, spreading eastward to Chokkadabail reserve where it is most abundant and forms about 85 per cent of the crop over an area of about $4\frac{1}{2}$ sq. miles. South of Balehalli forest it occurs scattered here and there as far as the boundary of Chikkamagalur district. Here it is found again in a highly pure state in the forests of Sringeri *Jahagir*. There is also an excellent though limited growth of *Hopea* near Alsi in the

interior of Tirthhalli *taluk*. *Hopea* then extends to the evergreens of Hassan ghats where it is fairly common in the fore-hills zone of Bisle and Kemphole forests (*Ind. For.*, Feb. 1950, p. 2).

In Coorg it is found in the Western Ghats starting from Pushpagiri at the north-west corner of the State to Brahmagiri its most southerly point. In Madras State it is found in the Western Ghats and its forehills of the South Kanara district which has been called the "*Home of Hopea*", also in Malabar district and in the reserved forests of Tirunalvely *cum* Ramnad forest division. In Travancore-Cochin it is found in the ghat evergreen and semi-evergreen forests, sometimes occurring in the form of pure patches on the upper, southern slopes of the Balmoral ridge in the Kulthapuzha reserve of Shenkottah division. (M. N. Menon).

Hopea thrives at elevations ranging from almost sea-level to 3,000 feet or more in the hills. It is essentially a semi-shola tree, often found in mixture with deciduous trees although it is not really at home here. It finds a suitable habitat chiefly on the upper slopes and ridges or at the edge of the forest in the evergreen zone, and in the moist deciduous or semi-evergreen zone it occurs on the more gentle, undulating slopes of the foot-hills or on the rolling country of the tableland of Deccan. In its natural habitat the absolute maximum shade temperature varies from 95° to 100°F., the absolute minimum from 60° to 65°F., and the extremes of rainfall from 35 to 300 inches or more, with optimum ranging from 100 to 150 inches.

Forest types and associate tree species—*Hopea parviflora* is a native of the "Western Tropical Evergreen" (Champion's 1*a* C3) and the west coast tropical semi-evergreen (Champion's 2*a* C2) types. The range of the distribution of *Hopea* can be roughly separated under three distinct zones each with its own ecological peculiarities. They are :

(1) *The coastland plains zone*, consisting of a narrow strip of undulating country running between the Arabian Sea coast and the Western Ghats whose elevation varies from sea-level to about 1,000 feet and where the rainfall is about 150 inches and soil gneissic or red loam being the weathered product of laterite.

(2) *The ghat zone proper*, consisting of the narrow strip of hills embracing the crest of the Western Ghats and facing the Arabian Sea at elevations varying from 1,000 to 2,000 feet. The underlying gneiss rock is covered with a laterite cap ; in some places there is gneissic loam of high quality consisting of the weathered product of the gneisses. Rainfall here is 250 inches or more.

(3) *The Deccan plateaux zone*, rising from an elevation of about 2,000 to 3,000 feet and more, with appreciably lower rainfall of 100 to 150 inches and having red ferruginous loamy soil.

In Zone 1—*Hopea* enjoys the optimum conditions of the ecological factors required for its development. The semi-permeable deep lateritic loam, the damp and very warm climate which is condusive to the rapid disintegration of leaf-litter and the medium heavy rainfall aid a rapid and healthy growth of *Hopea* and the quick establishment of its profuse natural reproduction. The tree is often found here in nearly pure (gregarious) patches. Typical localities of this kind are seen in the Someshwar, Kabladi and other reserves of South Kanara.

In Zone 2—The excessive rainfall and deep, moist humus soils of the valleys are condusive to the development of the climax type of evergreen vegetation causing keen competition for light and space in which *Hopea* is unable to develop its characteristically gregarious habit. The heavy humus layer also hampers the ready contact, which the radicle of the germinating seed of *Hopea* has to make with the mineral soil to establish itself. *Hopea* becomes, therefore, practically a minor component of the forest crop.

In Zone 3—In this zone, there are conditions resembling those of Zone 1, but the climate is generally cooler but drier and the soil is often shallow. The gregarious habit of *Hopea* often asserts itself here but its growth is not so rapid or luxuriant as in Zone 1. The Chokkadabail Reserve of Mysore and several shola forests of Wynaad, Malabar and Tirunalvely where the tree often occurs in highly pure patches, are examples. Both on the Malabar coast and on the Deccan tableland forests of Wynaad and Mysore *Hopea* is occasionally found in moist deciduous forests but is strictly confined to the banks of rivers; here it is associated with species like *Trewia nudiflora, Tetrameles nudiflora, Machilus macrantha, Eugenia* spp., *Vitex altissima,* various kinds of *Ficus* and occasionally, as in parts of Nilambur division, with *Artocarpus hirsuta.* (A. R. Brand, 1941).

The following are a few typical localities where the tree occurs and its associate trees in them :—

1. *Sharavati upper valley, Honavar range in North Kanara, Bombay State, Evergreen and semi-evergreen forest*—The chief associates of *Hopea parviflora* are: *Hopea wightiana, Diospyros* spp., *Artocarpus hirsuta, Knema attenuata, Sageraea laurifolia, Strombosia ceylanica, Carallia integerrima, Alstonia scholaris, Calophyllum elatum, Trewia nudiflora, Vitex altissima, Lagerstroemia microcarpa, Garcinia cambogia.* (S. S. Dhareshwar, July 1940).

2. *The Ghat crest region, Ghats of Shimoga and Sagar divisions,* Mysore State. Evergreen climax forest, at altitudes from 1,000 to 2,500 feet on the western slope of the Ghats, with *Poeciloneuron indicum, Hopea parviflora* and a host of others (Fig. 3). Here *Hopea parviflora* forms about 2 per cent of the crop. (K. Kadambi, April 1941).

3. *Chokkadabail bogi reserve, Agumbe range, Shimoga division,* Mysore State. Semi-evergreen forest. (Altitude 1,500 to 2,000 feet; rainfall – about 150 inches). Here *Hopea parviflora* occurs almost pure, and is associated mainly with *Hopea wightiana.* (V. Alvares, 1931).

4. *Fore-hills zone; Bisle and Kemphole forests, Ghats of Hassan division,* Mysore State. Evergreen climax forest. Principal trees: *Hopea wightiana, H. parviflora, Artocarpus hirsuta, Holigarna arnottiana, H. grahmii, Canarium strictum, Myristica malabarica.* (K. Kadambi, February 1950).

5. *Makut, Coorg*—Evergreen climax forest. Trees: *Vateria indica, Kingiodendron pinnatum, Dipterocarpus indicus, Cedrela* sp., *Mesuaferrea, Holigarna arnottiana, Mangifera* sp., *Artocarpus hirsuta, Dysoxylum malabaricum, Hopea parviflora, Calophyllum elatum,* all in the top story. (H. G. Champion, 35).

6. *Foot-hills of the Western Ghat Range, South Mangalore division*—Semi-evergreen forest, with *Artocarpus hirsuta, Hopea parviflora, Dalbergia latifolia, Xylia xylocarpa* and others. (P. W. Davis, 1934, 3).

7. *Someshwar, South Kanara*; Trees—*Terminalia paniculata, Diospyros* spp., *Lagerstroemia lanceolata, Holigarna arnottiana, Loptopetalum wightianum, Machilus macrantha, Cinnamomum* sp., *Hopea parviflora, Artocarpus hirsuta* and others. (H. G. Champion, 1936, 57).

8. *Semi-shola type, Wynaad Ghats, Wynaad division,* Madras—Trees: *Hopea parviflora* associated with *Tetrameles nudiflora, Artocarpus hirsuta, Acrocarpus fraxinifolius, Sterculia foetida* and several others. (A. N. Sarma, 1934).

9. *Western Ghats above Nilambur,* Madras—West coast tropical semi-evergreen forest (Champion's 2a Cl.) – Trees: *Terminalia paniculata, Xylia xylocarpa* – (on incompletely disintegrated laterite gravel), *Stereospermum chelonoides, Trewia polycarpa, Eugenia* spp., *Veteria indica, Canarium strictum, Hopea parviflora* and *Calophyllum elatum.*

FIG. 1

FIG. 5

DISTRIBUTION
OF
HOPEA PARVIFLORA, BEDD.

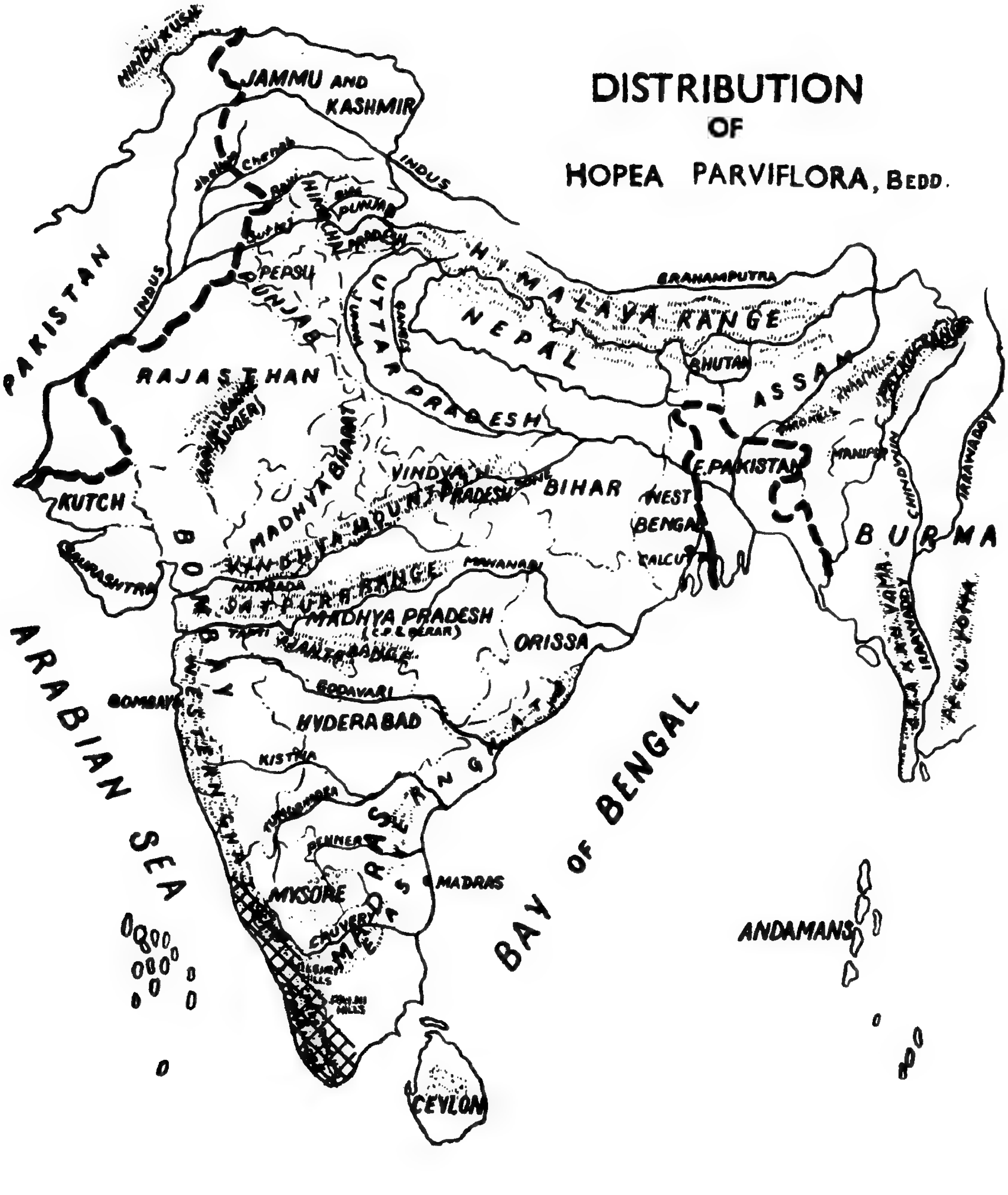
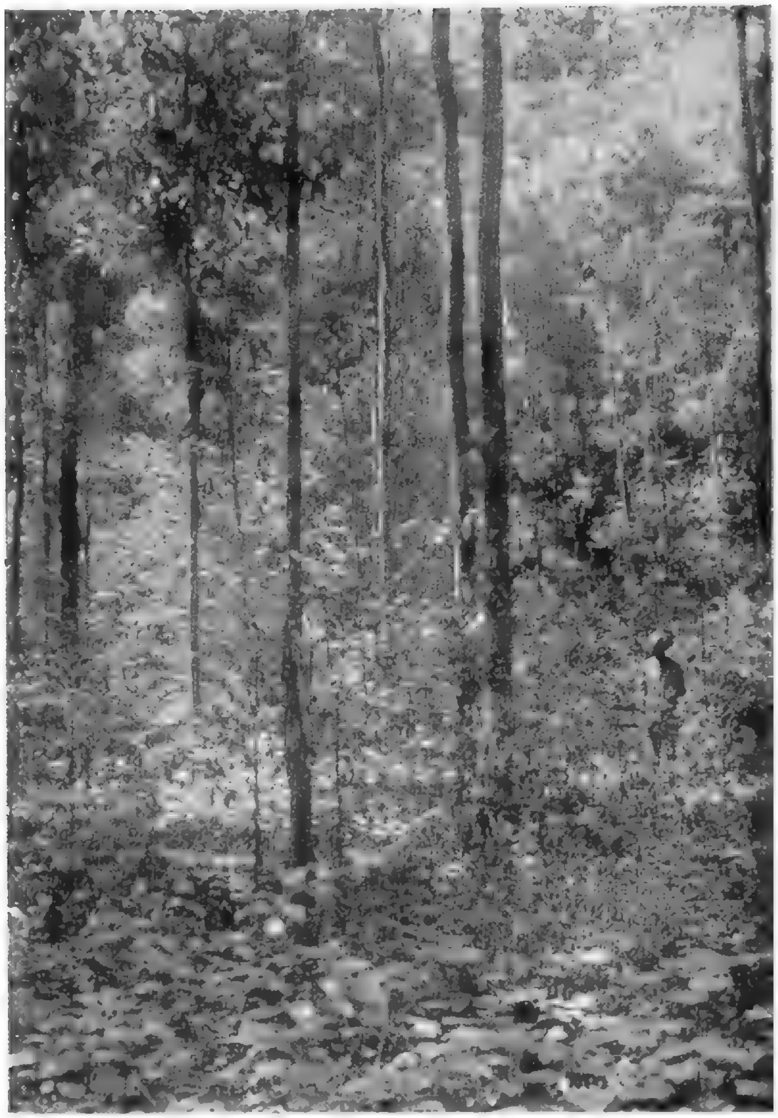


Fig. 2.

FIG. 3

FIG. 4



10. *Tunacadavu and Ulandadi* blocks, *Coimbatore* (*South*) *division, Palghat,* Madras—Comparatively dry shola type, with *Hopea* – *Mesua* association. *Hopea parviflora* and *Mesua ferrea* are found here in appreciable quantities. (T. V. V. Ayyar, 1942).

11. *Shenkottah division, Travancore-Cochin*—Evergreen and semi-evergreen forests. In the former type *Hopea parviflora* is associated with *Cullenia excelsa, Dipterocarpus indicus, Dichopsis elliptica, Machilus macrantha, Mesua ferrea* and others. In the latter deciduous and evergreen species like *Terminalias, Lagerstroemia lanceolata, Holigarnas,* Toon, *Hopea parviflora, H. wightiana, Calophyllum wightianum* and others are found. (M. N. Menon, 1950).

12. *Ambasamudrum range sholas, Tirunalvely cum Ramnad division,* Madras—Semi-evergreen forest with three storeyed high forest. Principal trees of the top storey are : *Mesua ferrea, Cullenia excelsa, Gluta travancorica, Palaquium ellipticum, Hopea parviflora, Heritiera papilio, Dysoxylum malabaricum* and others. (E. A. Lasrado, 1936).

Rock and Soil—In the coastal zone of the South Kanara where *Hopea* has its home the underlying formation consists of metamorphic schists and crystalline gneiss with granite and quartzose intrusions. Extensive areas of laterite overlie the parent rock to various depths, often 30 feet or more, giving rise to a deep red loam when fully disintegrated. The principal rock under the cap of laterite throughout the Ghat forests where *Hopea* abounds is a granatoid—gneissic or gneissic formation, generally coarse grained and often highly quartzose. On the plateaux the gneiss is frequently found metamorphosed on the surface into yellowish or reddish, felspathic easily disintegrating rocks. Generally, in the region of the ghat-head there is a cap of laterite or lateritic or ferruginous loam or clay variously coloured from white, through yellow to even black, the last resulting from the admixture of manganese in pockets.

Leafing, flowering and fruiting—Although evergreen, the tree loses a portion of its old leaves at the onset of the dry season from December–January and onwards up to April or even May in hill sholas. At the same time the tree develops a strong flush of new leaves in January–February (December–January in hill sholas, A. L. Griffith) which causes the tree to be quite conspicuous at this time among its surrounding ones. The small, cream coloured fragrant flowers appear in January–February (February in Mysore Ghats – K. Kadambi ; February–March in Wynaad Ghats – A. N. Sarma) and the fruit ripens by the end of May or in June. The light fruit has two straw coloured wings less than 2 inches long, the nut being 0·25 inch long. It is thus capable of being dispersed by wind over a considerable distance. If there has been much rainfall at the time of ripening of the seed the wings of the fruit remain green although the fruit is fully ripe and germinates (D. T. Barry). The tree seeds freely at frequent intervals ; so far as can be judged from the records available it appears that prolific seeding occurs once in 4 to 6 years and such years are invariably followed by one or two years of comparative sterility and an intermediate year or two when seed is produced in moderate quantities. About 70 seeds weigh one oz. (F.R.I.) ; 82 seeds per oz. (Madras Res. Rpt., 1939–40).

Under natural conditions the seeds lose their germinative capacity in a few days (about a week) after reaching the ground and this is stated to be due to the cotyledons developing chlorophyll even when they are within the seed ; they therefore, germinate soon after reaching the ground, provided that the conditions required are favourable.

Germination—Epigeous. The covering of the fruit cracks and the radicle comes out of its apex and curves rapidly downwards to form a tap root. The fleshy cotyledons are borne above ground on the elongated hypocotyl which withdraws them from the seed in this process. The young shoot appears in-between them.

The seedling—Roots : primary root moderately long and thick terete, tapering, woody lateral roots moderate in number or numerous, short to long, fibrous, distributed down the main root. *Hypocotyl* distinct from the root, 0·8–1·5 inches long, terete, slightly fusiform, minutely tomentose. *Cotyledons* ; petiole 0·15 inch long, thick, somewhat flattened, minutely pubescent ; lamina divided nearly to the base into two thick fleshy angular lobes 0·25–0·4 inch long, stem erect, terete, woody, young parts minutely tomentose. Internodes, first (between cotyledons and first foliage leaves) 1·5–2·5 inches long, subsequent internodes 0·1–1·3 inches long. *Leaves*, first pair opposite, subsequent leaves alternate. Stipules 0·05–0·1 inch long, narrow triangular, acuminate, tomentose, caducous. Petiole 0·1–0·15 inch long, minutely tomentose. Lamina, first pair 1·2–1·9 inches by 0·35–0·6 inch, subsequent leaves 0·7–2·7 by 0·25–0·9 inches long, ovate lanceolate, acute or acuminate, base rounded or acute, entire, glabrous, but midrib on under surface of young leaves minutely pubescent and margins sometimes with a fringe of minute hairs ; lateral veins 6–12 pairs.

Silvicultural characters—*Hopea parviflora* is not a heavy shade bearer at any stage in its growth. In its seedling stage it definitely benefits by shade, in its sapling stage it is a moderate light demander benefitting by diffuse light or side shade, while in the pole stage it benefits by direct light up to full exposure. Normally, recruitment of *Hopea* tends to disappear with complete clear-felling of the top canopy but, especially in tableland forests, established reproduction and saplings develop best in direct overhead light (Silv. Res. Rept., Madras, 1951–2, para 13, 1952–3, para 9) though diffuse light appears to be advantageous in the drier habitats and at lower, hotter elevations as in South Kanara district. Even here observation appears to show that in perennially moist situations *Hopea* reproduction is capable of healthy growth if directly exposed to overhead light. In general it may be stated that the greater the humidity of the locality throughout the year, the more pronounced is the demand for light intensity of the established regeneration. In evergreen forests the limiting conditions for *Hopea* growth are invariably due to inadequate light, this tree being intolerant of very heavy shade in moist situations even in its infancy. Davis says that under South Kanara conditions where humid heat prevails over the greater part of the year, partially diffuse light is advantageous to the growth of *Hopea* provided it has overhead freedom from surrounding vegetation (Working Plan, p. 24). The tree grows on both gneissic and lateritic soils and has its optimum conditions in a deep ferruginous and not too heavy loam formed from the partially or fully weathered gneiss of the foot-hills or the red loamy laterite soils of the foot-hills, ghats and the Deccan tableland. The tree generally attains superior dimensions on good, deep, well-drained loam and it is not very particular as regards soil or aeration provided the initial biological and edaphic site factors are favourable.

The tree is fond of moisture and in the lower rainfall localities of its habitat it tends to develop best in the rich, moist alluvial soil alongside streams as these provide ideal conditions of soil and atmospheric humidity combined with the requisite degree of light (Fig. 4) but sometimes it grows in exposed situations which are fairly high and dry.

The tree is sensitive to the congestion (Mys. Ft. Jour., 1929, 7) ; weeds and undergrowth in evergreen forests account for the death of a large number of seedlings and saplings in early infancy. (V. Alvares, 1931, 7). The pole crop also thrives best in complete vertical freedom. Weeding is beneficial to the growth of seedlings and saplings (Silv. Res. Rpt., Madras, 1949–50, 13–17), and in the case of recruitment also soil working round seedlings tends to hasten its establishment. (E.P. 46 and 47, South Coimbatore, Madras). The coppicing power of *Hopea* is poor ; trees above 2 feet in girth have sometimes failed to coppice while these under this girth may coppice indifferently.

In favourable situations the tree is gregarious forming nearly pure forests. This tendency is clearly marked in all those areas where it grows in nature, though in the evergreen

climax forest at the head of the ghats the keen competition for space among trees prevents *Hopea* from developing this tendency.

Natural reproduction—The tree reproduces freely in nature. Limiting factors of soil moisture and light incidence interact on the growth of the young seedling for several years during its recruitment and establishment stages, less favourable moisture conditions increasing its demand for shade and *vice versa*. In South Kanara, and on the adjoining Mysore plateaux, reproduction of *Hopea* under mother trees is generally profuse in favourable years and in the pure patches which the tree often forms here reproduction is often prolific. Given the shade of the mother tree, a favourable seed crop and rainfall at the appropriate time when seed ripens, and a well-drained moist deep soil free from a heavy cover of leaf litter, abundant quantities of recruitment appear on the forest soil. Progress of this recruitment to the established seedling stage is encouraged by removal of weeds and low cover coupled with adequate but not direct illumination from above.

The large quantity of seed shed by the tree every few years is scattered by wind agency. The seed has little vitality and dies unless it soon finds conditions suitable for its germination. A gregarious tendency is also noticeable owing to the same reason. Natural reproduction is often markedly deficient in mature crops on evergreen slopes of shady aspect or along sheltered valleys but it at once becomes apparent in the surrounding forest wherever the forest canopy admits the requisite degree of light or aspect changes to produce similar effect. Wherever a belt or patch of mature timber exists on upper hill slopes a tendency may almost invariably be seen for the species to spread to lower slopes which have been cleared for agriculture in the past and later abundoned. Typical instances are seen in the Subrahmania, Kiribag, Bantamale, Alettii East and West and Sampije reserves of South Mangalore division (P. W. Davis).

Although the initial requirements for germination and seedling growth are well defined and limited, the interrelation of environmental factors within these limits seems to afford surprising scope for the development of natural regeneration. Thus, in South Kanara, *Hopea* has established itself under *Ochlandra* reed, in open grassy blanks, in typical moist deciduous forest, *Xylia* forest without the shelter of a middle-storey, in moist riverain belts and in sparsely stocked deciduous or scrub area. But, from none of these individual instances would it be at all wise to draw general conclusions for the purpose of extensive forestry practice. The only wise course is to ensure a safe average of conditions of humidity and light, a fact sometimes indicated by certain associations of flora. There are a few instances of the natural reproduction of *Hopea* forming an underwood in teak plantations. For instance, in Nilambur division, Madras, in Edacode compartment 83, about 5 acres contain a good, dense underwood of *Hopea*, standing partly on alluvium and partly on disintegrated laterite with out-crops of gneiss. The growth on laterite is denser and better than on alluvium. This natural regeneration is stated by R. S. Browne to have come from 4 mother trees on the river bank. (Nilambur Working Plan, 1938–53, 16). The tree often regenerates profusely in abandoned clearings where the soil has been disturbed and mineral soil exposed, its wind – dispersed seeds from neighbouring stands settling down and germinating readily in such places.

In South Kanara, where improvement fellings have been carried out during past years, *Hopea parviflora* being the most favoured species, the semi-permeable, deep laterite soil, the damp warm climate and the abundant rainfall coupled with the removal of leaf litter by the villagers, which practice is in vogue in private holdings, has almost invariably produced dense regeneration under parent trees. The seedlings grow under the parent trees for 2 to 3 years, after which the weeding and slight opening of the upper canopy practised give a spurt to their growth. The removal of the parent trees which then follows leaves behind a well established, even aged crop. In the Chokkadabyle Reserve of Mysore State, where *Hopea* is gregarious,

the long established local practice of collecting the fallen leaves for manurial purposes by the villagers exposes the mineral soil and prevents accumulation of a thick layer of debris and incidentally also keeps out the reproduction of other undesirable, fast growing annuals. Light, too, filters through the canopy to the soil in thin pencils, and this, coupled with the well-drained laterite soil induces prolific reproduction of this species. In the dense evergreen climax forest, such as what we find at the head of the Western Ghats, where mother trees of *Hopea* are few and far between, the natural reproduction gets shaded out or choked up under the thick cover of fast growing annuals and this, coupled with the heavy plant debris which retards the penetration of the radicle of *Hopea* seedlings into the soil during its germinating stages and also renders soil aeration difficult in the rainy season, present a handicap to the progress of *Hopea* seedlings. A few seedlings which find themselves by chance more favourably situated with regard to light requirements manage to establish themselves and compete favourably with the rest of the seedling regeneration in the race for light and space.

Starting, therefore, with unestablished recruitment, the best course to adopt to induce further recruitment and to establish the recruitment and make it progress into the pole stage in the quickest possible way under natural forest conditions appears to be :—

(1) to remove all weeds, undergrowth and middle-storey leaving only the top canopy trees.

(2) to lighten the top canopy as the regeneration moves to the establishment state.

(3) to clear-fell the top canopy when the regeneration is fully established and the saplings are moving on to the pole stage.

The general results of the experiments done so far on the subject indicate clearly that *till the natural regeneration reaches the established stage top canopy shade is beneficial ; thereafter the plants benefit by overhead light.* (Silv. Res. Rpt., Madras, 1951–52, para 9). However, in nature there is sometimes the danger to the regeneration of browsing by game animals, in localities abounding in game, if all the undergrowth is removed and the *Hopea* seedlings are thus exposed. In South Kanara it has also been found that the sudden removal of overwood when the *Hopea* crop is about 6 feet high exposes the plants to damage by insects borers (For. Res. Officer's B-D.s. 77/27, p. 7).

Artificial regeneration—Hopea parviflora can be raised by sowing seed and transplanting entire seedlings (Fig. 5) ; the latter appears to be more advantageous especially where a severe summer has to be tided over (Silv. Res. Rpt., Madras, 1939–40, p. 114 and 1942–3, p. 54) but, under favourable conditions sowing can give very good success. In fact, thousands of acres of *Hopea* plantation in South Kanara district have been raised by sowing seed, either at stake or broadcast, the former method being more economical for seed. For planting, 1 to 2 year old transplants are more advantageous than young ones 6 to 8 weeks old. (For. Res. Rpt., Madras, 1929). There is not much to choose between 1 and 2 year old plants, both being perhaps equally good. In Mysore 2 to 3 year old plants have been found to survive better than yearlings. (Mys. Ft. Journal, 1929, No. 3, 8). Stump planting is not advantageous because *Hopea parviflora,* in common with many other evergreens, does not stump satisfactorily, although there are stray instances in which up to 50 per cent stumps have come through (For. Res. in Madras, 1928–9). Shade is essential for both sowings and transplants in the first two or three years, and unless this is given in the form of cover crops or unless natural forest cover is available heavy casualties may occur. Efforts to raise *Hopea* by planting or sowing directly in the open are likely to fail (Expt. plot No. 27, Palghat Dn., Madras, final summary). Similarly, it is only with great difficulty that *Hopea* transplants or sowings survive the hot weather of places like Nilambur under a teak plantation unless there is already some evergreen undergrowth like *Glycosmis pentaphylla* which can nurse the *Hopea.*

(E.P. No. 6, Nilambur Division, Madras). Under *Xylia xylocarpa*, *Hopea* has a better chance of surviving the hot weather than under teak, but even then casualties in the hot weather are likely to be heavy. (E.P. No. 14, Nilambur). The tree has been raised on an experimental scale in deciduous, clear-felled and burnt areas with a nurse crop of *Tephrosia candida* and shade crop of *Trewia nudiflora* the former being the better treatment. (Silv. Res. Rpt., Mad., 1950–51, para 13, 51–52, para 9). After the *Hopea* plants are established it is advantageous to remove overhead cover and middle storey layers completely, though sometimes this operation results in some damage to *Hopea* seedlings by insects or game. The size or the time when the overhead canopy may be completely opened with advantage will depend upon the progress of the regeneration but, generally speaking this can be done when the plants are about 5 to 6 feet high. Weeding is definitely advantageous in bringing up a *Hopea* crop; both height growth and survivals are increased by this operation. One or two weedings ought to be enough (Silv. Res. Rpt., Mad., 1944–5, para 306).

The growth of *Hopea* during the early years of its life presents sometimes contrasts owing to the counteraction of the growth factors moisture and sunlight, the less favourable of these two being responsible for the limitation of its development according to circumstances. These factors are not yet quantitatively estimated but the following general observations may help to clarify the apparently contradictory behaviour of the species sometimes noticed in the field :—

(1) In the dense shade of evergreen forests the limiting factor for the germination and growth of the young plant is inadequate light or exessive moisture (in the ghat crest region) during the growing season, June to November, which is also the period of the heaviest rainfall. Here, overhead light throughout the year and side-shade during the hot months may help.

(2) In drier localities the limiting factor is deficiency in depth of soil; the drought during the hot months results in desiccation of the younger tissues which induces a bushy stunted habit and often ends in death. In such localities *Hopea* demands overhead and side-shade for the young plants until their root system is established well enough to carry it through the dry season.

(3) In deciduous forests where *Hopea* has been newly introduced, growth is likely to be delayed for several years because its root system will find it difficult to penetrate the upper soil layers, which may often consist of laterite. Soil working is likely to help under these circumstances.

In Parapa reserve of South Kanara, one of the more important centres of artificial regeneration operations in the past, *Hopea* was raised at the outset by broadcasting seed. Later this was replaced by sowing seed in staked patches made in lines cut through the undergrowth. In 1922 the method of sowing in large patches about 4 feet wide and 1 foot deep, at intervals of 27 feet and with 50 seeds in a patch, was tried. Subsequently pits 12 inches in diameter and 10 inches deep were dug at various espacements, *viz.*, 9×9 feet, $13\frac{1}{2} \times 13\frac{1}{2}$ feet, 19×19 feet and 27×27 feet and 10 seeds were sown in each pit. Casualties were replaced by nursery seedlings. The method of operations in other reserves has followed more or less the same course. In the Agumbe Range of Mysore State, planting entire seedlings of *Hopea* has been tried since 1920 in 6 feet wide strips cleared through the forest undergrowth. The 1 to 3-year old seedlings were planted in 1 foot cube pits made 10 feet apart in the lines. (Mys. Ft. Jour., 1931, p. 12). Success has been indifferent, depending mainly upon the subsequent tending given to the seedlings. Dibbling seed under bushes in open forests was also tried.

Nursery practice—The seed of *Hopea* does not stand storage; it has been stored for only 20 days in gunny bag without appreciable loss of viability. After 40 days viability

falls to zero. Germinative capacity of fresh seed is fairly high being 68 per cent, and the number of plants per lb. of seed is about 708 (Madras Silv. Res. Rpt., 38–9, 131–3). The seed should be sown immediately after collection in shaded nursery beds with the wings placed flat on the ground, and covered with earth. (Silv. Res. Rpt., Madras, 1938–9, 11). Removal of the wings does not adversely affect the germination. (Madras Res. Rpt., 1920–1). As monsoon rains are uncertain and may not always coincide with the time of seed-fall arrangements should be made for daily watering. Germination starts in about 10 days and is practically complete within about 20 days. No more germination may be expected after 6 weeks of the sowing. Medium to large sized transplants are known to succeed in transplanting better than small ones. Both forest and nursery transplants are equally good for transplanting. (Silv. Res. Rpt., Madras, 1942–3, 52). The best time for transplanting under canopy varies with the conditions of the locality but, in general, in evergreen forests with very heavy rainfall, July is too wet and unsuitable. Experiments in Madras have shown that the best date for transplanting under canopy is mid-June for Karianshola in South Coimbatore division, and mid-July for Chandanatode in Wynaad division. Weeding, including removal of climbers is advantageous if not essential, as *Hopea* does not tolerate congestion and grows best if free space is available for the crowns all round. *Hopea* needs a light to medium thinning when the plants are about 30–40 feet high and response to thinning is very good. In Nilambur, *Hopea* planted under a failed teak plantation on a pure laterite slope about the year 1934 had developed into trees with a mean height of 33·58 feet by 1950 when suppression had set in and a thinning appeared necessary.

Methods of management—According to the condition of the crop in them, the *Hopea* forests of South India are managed under the methods Selection fellings, Irregular Shelterwood fellings, Improvement fellings and the like. Selection fellings are generally in vogue, in the evergreen ghat forests of Madras in the divisions South Coimbatore (T. V. V. Ayyar) and Tirunalvely *cum* Ramnad, in the evergreen forests of Shencottah division of the State of Travancore-Cochin, in portions of the Ghat evergreen forests of Coorg (Van Haeften) and in the evergreen ghat forests of the Hassan, Shimoga and Sagar divisions of Mysore State. (K. Kadambi). The selection fellings practised are of the usual pattern being limited by exploitable girths carefully fixed with reference to the size which the *Hopea* trees can attain in a sound state ; this girth varies from 4½ feet in parts of Mysore to 6 or 7 feet in Madras.

The Irregular Shelterwood (with various modifications) has been applied to some of the forests of South Mangalore division in Madras, and to portions of the Chokkadabail bogi reserve and the heavily exploited portions of the evergreen climax forests of Shimoga and Sagar divisions in Mysore State. The fellings prescribed by Davis in the first division, namely South Mangalore, are a sort of compromise between the Uniform and Group methods on the one hand and Selection and Group-Selection methods on the other. (P. W. Davis).

In the Chokkadabail bogi reserve, the object of the shelterwood fellings prescribed is to free the abundant advance growth from the suppression of the over mature mother crop of *Hopea* trees. In the Agumbe – Kilandur zone, the main object of the Irregular Shelterwood fellings prescribed is to lift the evergreen canopy in three successive stages from below upwards, with a view to free the abundant natural regeneration and advance growth of *Hopea parviflora*, *Dipterocarpus indicus*, *Poeciloneuron indicum* and *Mesua ferrea* (Fig. 6) ; these stages are known as the *initial*, the *intermediate* and the *final* stages. In the *initial* stage all undergrowth and low trees up to a height of 30 feet, except the reproduction and pole crop of the *élite* trees, are cut. In the *intermediate* stage, generally, the middle layers of the canopy are removed and in the final stage all overwood stems of exploitable size are felled. (Working Plan, 1941–61, 137). Improvement fellings have in general, been prescribed for forests where young *Hopea* crops have established under the shade of non-descript secondary growth

of *kumri*, or where the young crop is otherwise in need of weeding, climber cutting, cleaning and freeing from the competition of inferior kinds of trees.

External dangers and protection Insects : young *Hopea* crops are open to the attacks of borers. Damage, however, is inconsiderable. Among the borers found in South Mangalore division, Madras, are :—

(1) *Xyleborus morastati haged*, known as the coffee borer in south India; this was found in Mundaje kap reserve of South Mangalore division, Madras. (2) An insect identified as *Sphaerotypes* which enters the stem and tunnels down to the root finally completely destroying the plant; this was found in Jalsur East reserve of South Mangalore division, Madras. Borers of young saplings and seedlings attack chiefly the weakly and suppressed specimens.

In a young crop insect attack to the cambium layer of young shoots is more widespread than borer attacks. The insect concerned gnaws at the surface tissue and generally succeeds in ringing the slender stem which is killed. The two insects thought responsible for the gnawing of the rind of twigs have been identified as a species of *Nodostoma* and a weevil *Eups nietneri* Jakel. A third, *Hyperaxis malabarica* Jacob has also been found on leading shoots. Numerous other insects attack the tender foliage of the seedling. Grasshopper nymphs are largely responsible for the semi-circular cuttings in the leaf. On felled timber the larvae of *Massicus venustus* Pasc (*Cerambycidae*) bore large, oval galleries in the heartwood. Another timber borer *Agroshynchus emaculatus* has also been found in South Mangalore division. (P. W. Davis).

The following injuries to *Hopea* are reported from Wynaad and the Tirunalvely *cum* Ramnad division :—

(*i*) Girdling of the shoot several inches below the apex by a ring of punctures attributed to a *Rhynchites* beetle.

(*ii*) Curling and death of shoots owing to isolated punctures and larger bites of variable extent caused by any mandibulate insect – beetle, caterpillar, grasshopper, etc.

(*iii*) Scars on shoots and distortion of shoots owing to feeding of insects on the cuticle of stouter shoots. (C. F. C. Beeson's tour notes, 1938, in Wynaad and Nilambur).

(*iv*) Death of *Hopea* poles probably by girdling caused by the borer *Massicus venustus*. The poles are attacked at a height of usually 3 to 4 feet from ground level. The larvae make extensive galleries in the sapwood spirally up and down when young and eventually bore 1½ inches into the wood to pupate. (Working Plan, 1934–5, 19).

Animals—Bison are responsible for some damage to seedlings and saplings which they trample, bend or break or whose leading shoots they eat. *Sambhur* strips the bark and cambial layer of saplings possibly as food but generally stags are fond of rubbing their horns along the stems causing broken, forked or malformed stems.

Rate of growth—The rate of growth of *Hopea* under favourable conditions in moderately fast, after the crucial early years of its establishment are over. This period may vary according to circumstances from 2 to 5 years but, normally a sapling starts putting on height after its second or third year. The following tables indicate the rates of height development which have been recorded in connection with various experiments carried out chiefly in Madras.

Hopea parviflora.—*Rate of height growth in a clear-felled, evergreen forest, South Coimbatore division, Madras*

Year	(1) Burnt, with *Tephrosia candida* cover		(2) Burnt, without *Tephrosia candida* cover		(3) Unburnt, with *Tephrosia candida* cover		(4) Unburnt, without *Tephrosia candida* cover		(5) Natural forest under-growth intact, not burnt	
	Trans-plants	Direct sowing	Trans-plants	Direct sowing	Trans-plants	Direct sowing	Trans-plants	Direct sowing	Trans-plants	Direct sowing
	Mean height in feet and inches									
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
1937	0 3·3	..	0 3·4	..	0 3·3	..	0 3·2	..	0 3·5	..
1938	0 2·3	0 2·0	0 2·3	..	0 2·5	0 2·4	0 2·7	0 2·5	0 2·9	0 3·2
1939	0 6·7	0 3·6	0 8·2	0 4·4	0 6·5	0 3·5	0 9·2	0 4·0	0 7·4	0 3·6
1940	0 10·4	0 5·8	0 11·7	0 3·9	0 10·8	0 5·2	1 2·5	0 4·8	0 10·5	0 5·2
1941	1 3·6	0 8·9	1 1·6	0 4·9	1 9·0	0 5·0	1 9·9	0 4·8	1 3·5	0 7·5
1942	1 11·0	1 4·0	2 1·0	0 10·0	2 1·0	0 11·0	3 7·0	1 0·0	1 9·0	1 2·0
1943	3 3·5	2 2·0	5 8·6	1 6·3	3 7·9	2 2·3	6 0·5	1 8·3	2 10·2	1 9·6
1944	4 7·8	3 6·9	8 5·6	1 11·6	5 6·4	7 1·0	9 1·6	2 5·3	4 0·5	2 8·9
1945	5 3·4	4 2·6	16 4·8	2 7·3	6 4·7	3 10·5	9 7·8	3 1·6	4 10·4	3 5·5
1946	6 11·6	5 4·8	12 3·6	3 3·2	8 10·5	5 7·0	11 5·0	4 7·2	6 10·3	5 4·2
1947	14 0·0	6 3·0	14 10·8	3 11·0	10 2·0	7 11·0	9 4·0	8 11·0	8 4·0	7 0·0
1948	13 10·8	12 9·6	14 6·0	7 6·0	13 6·0	11 2·4	16 6·0	9 4·8	10 10·8	8 4·8
1949	16 1·2	14 2·4	20 2·4	..	14 7·2	11 2·4	17 9·6	9 1·2	10 2·4	8 2·4
1950	17 9·6	16 7·2	21 7·2	..	16 3·6	12 10·8	19 8·4	11 0·0	12 9·6	9 7·2

Hopea parviflora.—*Rate of height growth in clear-felled and burnt deciduous forest areas with nurse and shade crops – Wynaad and Palghat divisions*

Year	(a)		(b)		(c)		(d)		REMARKS
	E.P. No. 167/1938 Palghat division		E.P. No. 41/1937 Wynaad division Nurse crop		E.P. No. 52/1938 Wynaad division		E.P. No. 60/1938 Wynaad division		
	Trema	*Tephrosia*	*Padauk*	*Tephrosia*	*Padauk*	*Tephrosia*	*Trema*	*Tephrosia*	
	Mean height		Mean height		Mean height		Mean height		
	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	
1937	..	..	..	..	..	..	..	..	Height measurements not recorded up to 1940. Under (b), and up to 1941 under (c) and up to 1942 in others.
1938	..	..	..	..	..	..	..	..	
1939	..	..	..	..	..	..	..	..	
1940	..	..	..	..	..	..	..	..	
1941	..	..	4·20	5·58	..	..	..	..	
1942	..	..	9·3	10·3	7·0	9·1	..	..	
1943	5·1	4·8	12·4	12·5	8·8	11·9	11·2	10·1	
1944	10·4	10·3	6·84	11·8	11·0	23·9	14·0	12·5	
1945	13·8	13·3	18·8	18·6	13·4	17·0	18·5	18·2	
1946	16·5	16·3	19·4	19·7	15·2	19·4	18·6	19·5	
1947	19·1	19·3	23·1	21·6	18·2	21·4	23·4	22·6	
1948	21·3	21·1	As most of the trees have reached a height of twenty feet and more, they were measured once in five years		20·4	24·0	28·7	26·7	
1949	24·8	23·4			20·7	24·8	29·5	29·0	
1950	25·3	25·2			25·8	29·9	32·2	32·7	
1951	27·7	25·8			28·7	31·4	35·0	35·8	

N.B.—*Padauk* was planted when *Hopea* trees failed during 1940.

Hopea parviflora.—Height development through sapling to pole stage, Wynaad division. (E.P. 45, 1938), Madras

Year	Mean height
	ft.
1938	5·43
1939	7·19
1940	9·89
1941	11·44
1942	13·51
1943	15·24
1944	16·14
1945	18·12
1946	19·00
1947	19·53
1948	20·50
1949	21·77
1950	22·80
1951	13·5
1952	24·0

Hopea parviflora.—Height growth of established seedlings under various treatments, South Coimbatore division, Madras

Treatment	Clearfelling all except *Hopea* regeneration	Only top canopy shade retained	Control	Only top canopy shade retained	Clearfelling all except *Hopea* regeneration
			Heights in feet		
1938	4·38	4·62	4·29	4·98	4·99
1939	4·79	5·03	4·42	5·87	6·29
1940	5·71	5·88	4·71	7·00	8·20
1941	7·47	7·17	5·05	7·98	10·28
1942	8·86	8·29	4·88	9·00	12·00
1943	9·96	10·00	5·22	9·65	13·85
1944	11·23	10·44	5·86	10·04	15·08
1945	12·32	11·00	6·04	10·65	16·59
1946	14·60	12·25	6·30	10·80	18·07
1947	16·60	12·25	6·90	11·75	19·50
1948	18·50	14·17	7·70	12·25	20·70
1949	20·40	15·30	8·50	12·90	22·40
1950	20·70	15·80	8·40	13·10	23·90
Total increment in 12 years (ft.)	16·32	11·18	4·11	8·12	18·91
Mean annual increment (ft.)	1·36	0·93	0·34	0·68	1·58
Current annual increment (ft.)	0·30	0·50	0·10	1·10	1·58

P. W. Davis has recorded the following mean diameters and heights of a plantation crop of *Hopea* in South Mangalore division, Madras. The plantation was started in 1894–5 as an underwood to a 17-year old teak plantation standing on moderately deep soil varying from alluvium to laterite.

Hopea parviflora.—Rate of diameter and height growth

Year of measurement	Mean diameter in.	Mean height ft. in.
1911	4·75	..
1916	6·11	..
1921	7·67	51–10
1927	9·83	61–5½

As a result of measurements taken by him in various sample plots, Davis has estimated that in South Mangalore division *Hopea* trees standing on good deep alluvium or clay put on an annual diameter increment of about 0·5 inch (1·5 inches girth), and that on more rocky soils this increment is about 0·22 inch (0·7 inch girth). The average annual height increment of a pole crop has been estimated to vary from 1 to 1½ feet (Working Plan, p. 98). The height curves constructed by Davis indicate that *Hopea* seedlings attain a height of about 1 foot in 2 years, 2 feet in 3 years and thereafter they grow about a foot a year until about the 10th year. In Honavar range of North Kanara, Bombay, transplants 32 months old attained an average height of 3 feet 4 inches.

The following growth figures have been taken from the sample plots maintained for the species in North Mangalore division, Madras.

Hopea parviflora.—Periodical Sample plot measurements

Date of measurement	Crop age years	No. of trees per acre after thinning	Crop height ft.	Main crop average diameter in.	Basal area per acre after thinning sq. ft.	Total volume per acre c.ft.	Locality factors
			Sample Plot No. 1, North Mangalore division				
Oct. 1921 ..	26	455	57	5·4	72·5	2,135	Pilarkhan R. F., Karkal Range. Altitude 150 ft. Rainfall – 150 in. Soil Laterite. Pure pole crop of *Hopea* resulting from conversion of a mixed deciduous forest by cutting out unwanted trees and sowing *Hopea* seed.
Feb. 1927 ..	31	364	..	6·5	83·6	..	
Nov. 1933 ..	38	300	67	7·7	97·8	3,312	
Dec. 1939 ..	44	300	..	8·0	104·0	..	
May 1946 ..	50	217	78	9·6	109·1	..	
			Sample Plot No. 2, North Mangalore division				
Oct. 1921 ..	29	350	58	5·6	59·6	1,780	Do. as above.
Feb. 1927 ..	34	269	..	6·7	65·2	..	
Nov. 1933 ..	41	202	68	8·0	70·6	2,398	
Dec. 1939 ..	47	202	..	8·3	75·8	..	
May 1946 ..	53	136	78	9·8	71·5	..	
			Sample Plot No. 3, North Mangalore division				
Feb. 1922 ..	39	185	61	6·4	41·3	1,273	Do. as above.
Feb. 1927 ..	44	179	..	7·4	53·6	..	
Nov. 1933 ..	51	150	65	8·8	63·2	2,118	
Dec. 1939 ..	57	150	..	9·2	68·8	..	
May 1946 ..	63	95	76	11·1	63·7	..	

The following figures of the rate of growth of *Hopea parviflora* in North and South Mangalore divisions, Madras, were calculated from the Sample Plots records maintained at the Forest Research Institute, Dehra Dun. It will be seen that trees in the tree increment plot No. 1 of South Mangalore (column I) are faster grown compared to all trees of the other sample plots. The former were raised by under planting teak when the *Hopea* crop was 14 years of age and consisted mostly of dominant stems of *Hopea*.

Diameter at breast height	I Tree increment plot No. 1 of South Kanara		II Data devived from Sample plot Nos. 1–3, North Mangalore, and Tree Increment plots 2, 3 and 5 of South Mangalore	
inches	5 yearly increment	Age	5 yearly increment	Age
3	..	..	0·4	..
4	1·5	14	0·5	..
5	1·6	19	0·6	18
6	1·7	23	0·7	26
7	1·7	26	0·8	32
8	1·8	28	0·9	38
9	1·8	31	1·0	43
10	1·8	33	1·1	48
11	1·8	35	1·2	53
12	1·7	37	1·2	57
13	1·7	40	1·2	61
14	1·7	42	1·2	65
15	1·6	44	1·2	70
16	1·6	46	1·3	74
17	1·6	48	1·3	78
18	1·5	50	1·3	81
19	..	52	1·3	85
20	..	55	1·3	89
21	..	..	1·3	93
22	..	..	1·3	97
23	..	..	1·3	1·1
24	..	..	1·4	104
25	..	..	1·4	108

The following rate of girth increment in the increment plot maintained for *Hopea* in the Chokkadabail bogi reserve, Shimoga division, Mysore State is on record. (K. Kadambi, Working Plan, 1941–61, p. 181).

Girth class ft. to ft.	No. of trees on which figures are based	C.A.I. in inches	REMARKS
½ – 1½	46	0·18	The fall in increment of the 6–7½ feet girth class is probably due to the trees becoming unsound at about the size of 4½ feet which is also the exploitable size fixed for *Hopea* in these forests.
1½ – 3	215*	0·22	
3 – 4½	22	0·27	
4½ – 6	10	0·29	
6 – 7½	1	0·16	

The rate of girth increment on the Mysore tableland appears to be lower than in the best localities of the adjoining South Kanara sea coast district of Madras.

The following girth increment figures have been recorded for *Hopea* by Van Haeften in Coorg forests (Working Plan, p. 34).

Hopea parviflora.—Girth increment in Coorg

Tree No.	Original girth in 1924	Measurements in						Increment per year in inches	Situation
		February 1925		August 1934		March 1937			
	ft.	ft.	in.	ft.	in.	ft.	in.		
8	1–2	2	8½	4	6½	4	11½	2·2	On the left side of Matre path in Teak plantation.
4	1–2	2	2¼	3	3½	..		1·5	On the right side below central inspection path of teak plantation, near the well.
10	1–2	2	5⅜	3	3	..		1·05	On right of Makut, Matre path and North-East of Aini 32.
7	1–2	2	5½	3	11¼	..		1·97	Left of Matre path and North-East of Aini 32.
1	1–2	2	3½	3	3	..		1·3	Below road from Makut bungalow after passing hair pin bend.
12	2–3	2	10⅝	3	7¾	3	10	0·95	Right of Matre path.
11	2–3	3	3⅞	4	3	..		1·2	On left of Matre path beyond rubber estate.
16	2–3	3	5	5	0½	..		2·2	Towards the South of tram line at ½ and 71 feet from it.
23	2–3	3	11½	5	1¾	5	3½	1·34	In Thalapatti–Irupu area.
40	3–4	..		4	3¼	4	8⅛	1·6	North of the road to E.A.C.'s quarters at Urti.
26	4–5	5	4⅜	6	10½	7	2⅜	1·9	In Thalapatti area.
37	4–5	4	10⅞	5	7¾	..		2·3	In Thalapatti area.
33	5–6	6	1⅝	7	11	8	5¼	2·3	In Thalapatti–Irupu area.
44	5–6	..		6	9¼	6	11⅛	0·75	On the North of Irupu No. 43.
51	5–6	..		6	10½	7	0¼	0·5	In Thalapatti–Irupu area.
59	5–6	..		6	6¾	6	9½	0·8	In Thalapatti–Irupu area.

Commercial Volume and out-turn—The following out-turn of volume per tree has been worked out by P. W. Davis for *Hopea* in South Mangalore division, Madras (Working Plan, p. 99).

Hopea parviflora.—Volume of converted timber

Girth class ft. to ft.	Volume c. ft.	REMARKS
2 – 3	15	Exploitable size 7 feet.
3 – 4	27	
4 – 5	43	
5 – 6	62	
6 – 7	88	
7 – 8	128	
8 – 9	174	
9 – 10	220	
10 – 11	264	

The following Commercial out-turn figures have been worked out by K. Kadambi from the felling figures of Hosnagar range, Sagar division, Mysore State (Working Plan, p. 91).

Girth class ft. to ft.	No. of trees on which the results are based	Total commercial out-turn of round timber c.ft.	Out-turn of sawn materials c.ft.	Round timber volume per tree c.ft.	REMARKS
4½–6 (average 5 ft. 3 in.)	960	37,546	14,398½	39·1	Exploitable size of trees 4½ ft.

Utilization—General characters of the wood.—Hopea parviflora is a reddish-brown timber turning on exposure to dark reddish-brown colour with a purplish cast; it has occasional white lines. The wood has a smooth feel and takes good polish. It has no characteristic odour or taste, is heavy to very heavy (S.G. 0·70), interlocked grained and fine textured but hard and difficult to saw and work. "A non-ornamental timber of the first class". (Pearson and Brown). Owing to its strength and durability this timber has been in demand for a long time. Moderate supplies are available on the west coast, the yield from South Mangalore division having been estimated at about 3,000 tons (P. W. Davis) and for the rest of Madras State the yield may be assumed to be another 600 tons or so. The yield from Coorg has been estimated at 200 tons while in Mysore State about 240 tons would be available if all the forests containing this timber could be worked. The wood weighs at 12 per cent moisture 62 lbs. per c.ft. (58 lbs.: V. D. Limaye).

Seasoning—The timber seasons well. It is best converted green to prevent borer damage and the produce stacked in shade to dry.

Strength—The wood is much stronger than Burma teak as the following comparative figures show. (V. D. Limaye, p. 18).

Hopea parviflora.—Comparative properties expressed with teak taken as 100

	Locality	Weight in lbs./c.ft.	Strength as a beam	Stiffness as a beam	Suitability as a post	Shock resisting ability	Retention of shape	Shear	Hardness
Teak ..	Burma and Malabar ..	43	100	100	100	100	100	100	100
Hopea parviflora	South Mangalore (Madras) ..	58	120	120	120	130	65	155	200

Durability—One of the most durable of Indian timbers ; it is termite proof and very lasting in contact with earth and water even in worst climates.

Uses—The wood is used in every kind of construction; extensively used for house building, for ships in all their parts and as piles for bridges; also used for road tampers and rice pounders, and occasionally as mining timber in the Kolar Gold Mines of Mysore. Its versatility of use in localities where it has its home in Mysore state has fetched for it here the name "*malnad teak*". It can be used for all purposes where durability and strength are of importance. It has also been extensively used for railway sleepers but is probably too valuable to be sacrificed for that purpose. A few trees from the Agumbe area of Mysore have been exploited for electric transmission poles by mistake, but being a very valuable constructional timber of *malnad* areas its exploitation for poles has been generally discouraged.

Minor forest products—The bark of *Hopea* tree contains a high percentage of tannin ; next to wattles, Myrobalans and divi-divi, it is probably the richest in tanning materials containing 26 to 28 per cent tannin. The amount of tannin found in the bark is about five times that of the non-tannins in it. This high proportion of tannins to non-tannins renders the material suitable for the preparation of extracts, and a solid extract containing as much as 66 per cent tannin has been prepared from it.

The leather produced from this bark is said to be of a reddish tinge, of rather variable quality, not quite suitable for export to Europe. Better results are said to be obtained from Wattle bark which is imported as cheaply as *Hopea* bark could be supplied from forests. (P. W. Davis, 34).

The average yield of dry bark per tree of *Hopea parviflora* between 5 and 8 feet in girth in Someshwar reserve, South Mangalore division, Madras has been estimated at 573 lbs. (For. Res. Rpt., Madras, 1927–8, 219). The possible yield of bark from South Mangalore division is estimated at 60 to 70 tons per annum.

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ILLUSTRATIONS

FIG. 1.—*Hopea parviflora*, natural pole crop on unreserved land showing gregarious habit and the characteristic crown shape which is often compared to that of a South Indian temple car.

Photo – H. G. Champion, Madras.

FIG. 2.—Map showing the distribution of *Hopea parviflora* in India.

FIG. 3.—Moist tropical evergreen forest, Agumbe, Mysore. The heavy canopy, broken on the right owing to a cart-track, is letting-in a flood of light. *Dipterocarpus indicus* (whitish, straight bole in the middle back-ground) *Mesua ferrea* (large bent tree to the left) *Hopea parviflora* (straight tree adjoining it) and *Poeciloneuron indicum* (last three trees to the right).

Photo – author, 1934.

FIG. 4.—*Hopea parviflora* – Natural pole crop on alluvial flat which came up after heavy fellings in 1925. Utri, R.F., South Coorg.

Photo – M. V. Laurie, 1935.

FIG. 5.—*Hopea parviflora* at Chandanatode, Madras, transplanted in tropical evergreen forest under top canopy ; 3 to 7 feet high ; age about 3½ years.

Photo – M. V. Laurie, 1937.

FIG. 6.—Group of *Hopea parviflora*, natural saplings in a felling gap, Agumbe State Forest, Mysore. The two mother trees are in the foreground. Removal of the overhead trees is now very essential.

Photo – Author, 1934.

INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART XXI.—SODA PULPS FOR WRITING AND PRINTING PAPERS FROM *THEMEDA CYMBARIA* HACK. (ELEPHANT GRASS)

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SUMMARY

Laboratory experiments on the soda pulping of *Themeda cymbaria* Hack. (Elephant grass) are described. The average fibre length of the pulp from this grass is 1·08 mm. Easy bleaching pulps with satisfactory strength properties could be prepared under suitable conditions of digestion. The yields of bleached pulps were higher when the intermediate treatment with caustic soda was omitted during the bleaching process. This grass is reported to be available in sufficiently large quantities for utilization for paper manufacture in the low rolling area of the deciduous forests of the Travancore-Cochin State. The investigation reported in this bulletin has shown that *Themeda cymbaria* Hack. is a promising fibrous raw material for the manufacture of white writing and printing papers. The results of these experiments require to be confirmed by pilot plant trials.

INTRODUCTION

Themeda cymbaria Hack. is a stout perennial grass, 3–8 feet high. It is some times known as "Elephant grass" because of its long stem. The stems of this grass are erect, smooth and clothed at the base with broad, strongly compressed overlapping leaf sheaths. The internodes are long and the nodes are smooth or slightly hairy. The leaves are linear, 2–4 feet × 1/6–1/4 inch, finely pointed and somewhat rough on the margins. The sheaths are keeled, smooth and usually bearded at the mouth. The ligules are large and reddish. The inflorescence is 1–2 feet long and excessively sub-divided.

This grass is distributed in the Western Peninsula in India and also in Ceylon. It is reported to be very common in the low rolling area in deciduous forests in the Travancore-Cochin State and according to one estimate, this grass is found in an area of about 20,000 acres in that State. Hence, the Punalur Paper Mills, Ltd., requested this Institute to undertake an investigation on the pulping of this for paper manufacture. The results of this investigation are recorded in this bulletin.

THE RAW MATERIAL

The grass (50 lb.) was supplied by the Punalur Paper Mills, Ltd., Punalur, from an area along the Madatharai–Pinnamannar Road in the Kulathupuzha Reserve, Quilon Division, Travancore-Cochin State. The average length of the culm was about 6 feet. The colour of some blades was greenish-yellow and of others brownish. The moisture content of the grass as received was about 19% (on the oven-dry basis of the material). The grass was identified as *Themeda cymbaria* Hack. by the Botanist of this Institute. The grass was chopped into about one inch lengths and was screened on a 4-mesh sieve to remove small pieces and fines. The chopped and sieved grass was used for the proximate analysis and digestions.

PROXIMATE CHEMICAL ANALYSIS

The chopped grass was converted into dust in the usual way. The dust passing through 60-mesh and retained on 80-mesh was used for the proximate chemical analysis employing the TAPPI standard methods. The results of the analysis are recorded in Table I. The average moisture content of the dust was about 13% (on the oven-dry basis).

TABLE I

Proximate chemical analysis of Themeda cymbaria

	% on the oven-dry basis
1. Ash ..	2·80
2. Cold water solubility	9·29
3. Hot water solubility	11·05
4. 1% NaOH solubility	33·50
5. Ether solubility	1·39
6. Alcohol-benzene solubility..	5·83
7. Pentosans	22·05
8. Lignin	21·55
9. Cellulose (Cross and Bevan)	55·90

These results suggested that this grass might be tested for its suitability for chemical pulping.

FIBRE DIMENSIONS

The grass was digested by the soda process using 19% caustic soda (on the basis of the oven-dry material) at 162°C. for 6 hours. The pulp was bleached with bleaching powder using the intermediate alkali treatment described later in this bulletin. This pulp was used for determining the fibre length and diameter. Two hundred determinations were made in each case employing the usual procedures followed in this laboratory. The values of the fibre dimensions are given in Table II. The fibre length distribution is given in Table III and the fibre diameter distribution in Table IV.

TABLE II

Fibre dimensions

	Fibre length mm.	Fibre diameter mm.
Minimum ..	0·50	0·0099
Maximum ..	2·49	0·0198
Average ..	1·08	0·0135

The ratio of the average fibre length to diameter = 80 : 1.

TABLE III

Fibre length distribution

Fibre length mm.	Number of fibres	% of fibres
0·50 to 1·00	92	46·0
1·01 to 1·50	89	44·5
1·51 to 2·00	13	6·5
2·01 to 2·50	6	3·0
TOTAL	200	100·0

TABLE IV

Fibre diameter distribution

Fibre diameter mm.	Number of fibres	% of fibres
0·0099 to 0·0125	70	35·0
0·0126 to 0·0150	75	37·5
0·0151 to 0·0175	35	17·5
0·0176 to 0·0198	20	10·0
TOTAL	200	100·0

PRODUCTION OF PULP

Several digestions were carried out by the soda process using about 200 g. chopped grass each time. The material-liquor ratio was 1 : 6. The digestions were carried out using 15%, 17% and 19% caustic soda on the basis of the oven-dry material. The temperature of cooking was varied from 142° to 162°C. except in the case of the 15% cooks where 142°C. was not tried. The period of cooking was 6 hours ; this includes the period of one hour required for raising the temperature to the maximum cooking temperature. When 19% caustic soda was used for cooking, the digestions were carried out for 4 and 5 hours also.

The digestions were carried out in a mild steel autoclave and the pulps were bleached with bleaching powder in two stages. In the first stage, about 75% of the total bleach was used at 35°C. After the first stage of bleaching was completed, the partially bleached pulp was washed and treated with 2% caustic soda (on the basis of the oven-dry pulp) at 70°C. for 1 hour. The second stage of bleaching was carried out at the room temperature. In three cases, bleaching was carried out without the alkali treatment to find out the increase in the yield of bleached pulps when this treatment was omitted.

The bleached pulp was beaten in the Lampen Mill and standard sheets were made on the sheet making machine recommended by the British Paper and Board Makers' Association. After drying in the air using plates and rings, the standard sheets were conditioned at 65% R.H. and 68°F. and tested for their strength properties. The brightness of the pulp sheets was determined using the Photoelectric Reflection Meter Model 610.

The digestion conditions, pulp yields, bleach consumption, and strength properties and brightness of standard pulp sheets are recorded in Table V.

TABLE V.—*Soda digestions of Themeda cymbaria*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals*	Concentration of chemicals	Digestion temperature	Digestion period	Consumption of chemicals*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder containing 35% available chlorine*	Bleached pulp yield*†
	%	g./litre	°C.	hours	%	%	%	%
1	15	25	153	6	13·7	46·7	5·8	31·1
2	15	25	162	6	14·1	44·5	6·2	30·7
3a	17	28·3	142	6	13·5	47·9	4·1	35·9
3b	17	28·3	142	6	13·3	47·9	4·1	38·5
4a	17	28·3	153	6	14·7	44·5	4·7	33·3
4b	17	28·3	153	6	14·7	44·5	4·7	34·3
5	17	28·3	162	6	15·6	43·1	4·8	28·7
6	19	31·7	142	4	14·0	46·9	4·9	35·5
7	19	31·7	153	4	15·1	46·9	5·5	35·0
8	19	31·7	162	4	16·3	45·4	5·7	33·1
9	19	31·7	142	5	15·3	45·4	4·7	33·1
10	19	31·7	153	5	16·0	45·4	4·9	33·1
11	19	31·7	162	5	16·5	45·4	5·0	33·1
12a	19	31·7	142	6	16·0	45·3	3·0	31·5
12b	19	31·7	142	6	16·0	45·3	3·0	35·7
13	19	31·7	153	6	16·2	43·9	3·6	30·0
14	19	31·7	162	6	16·7	41·7	4·6	27·8

* The % is expressed on the basis of the raw material (oven-dry).

† When shives were present in the pulp, these were removed by hand picking before bleaching. The yield of the bleached pulp recorded in column 9 does not include the shives which were removed,

and strength properties of standard pulp sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 68°F.

10	11	12	13	14	15	16	17	18
Freeness of pulp	Basis weight	Breaking length (Schopper)	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding endurance (Schopper)	Brightness	REMARKS
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds		
290	59·2	..	4·5	98·8	71·2	600	..	Some shives were present.
290	60·0	..	4·0	96·6	70·9	630	66	A few shives were present but the pulp was better than in Serial No. 1.
315	60·0	8780	5·0	95·8	70·4	580	69	Some shives were present.
315	59·2	8770	4·0	90·0	70·8	520	66	Some shives were present. Intermediate alkali treatment was not used during bleaching.
280	62·0	9610	4·5	94·0	60·5	490	72	Well-cooked pulp.
305	60·0	9930	4·5	91·7	66·8	750	62	Well-cooked pulp. No intermediate alkali treatment during bleaching.
320	58·0	7830	4·5	87·9	52·4	280	69	Well-cooked pulp.
285	58·4	9700	3·5	85·6	60·8	370	73	A few shives were present.
280	59·6	9280	4·0	75·5	48·8	250	74	Do.
285	60·8	8330	3·0	74·0	52·0	180	74	A very few shives were present.
315	59·6	9060	4·0	90·6	55·0	360	75	A few shives were present.
310	61·2	9990	4·0	81·7	48·4	320	72	A very few shives were present.
290	59·6	..	4·0	81·7	49·2	330	71	Do.
295	58·0	8740	5·0	86·2	61·0	670	70	Well-cooked pulp.
310	62·0	8860	5·0	81·9	63·0	600	64	Well-cooked pulp. No intermediate alkali treatment during bleaching.
295	58·8	8830	4·5	85·0	62·6	600	71	Well-cooked pulp.
305	60·0	6300	5·0	61·7	47·8	55	70	Over-cooked pulp.

DISCUSSION

From the results recorded in Table V it is clear that the yields of the pulps decreased when the temperature of cooking was increased from 142° to 162°C., especially when the period of cooking was 6 hours. The yields of the bleached pulp were higher when the intermediate treatment with alkali was omitted during bleaching ; the whiteness of the bleached pulp was, however, less in the cases where the alkali treatment was not given. The bleach consumption increased slightly when the temperature of cooking was increased from 142° to 162°C.

Generally, the breaking length of the pulp increases when the temperature of cooking is increased from 142° to 153°C. and decreases when the temperature is further increased to 162°C. Other strength properties decrease generally with the increase in the temperature of cooking from 142° to 162°C. The conditions of digestion recorded in Serial No. 14, Table V, seem to be too drastic for the pulping of this grass ; in this case, the pulp was over-cooked and the strength properties of the pulp were poor compared to those of other pulps from this grass.

Under the conditions studied, the temperature of 153°C. seems to be preferable and the conditions given in Serial Nos. 4, 7 and 10, Table V, seem to be the most suitable for the pulping of this grass.

The results obtained in the laboratory experiments must be confirmed by carrying out pilot plant trials.

CONCLUSIONS

1. Easy bleaching pulps with satisfactory strength properties can be prepared by the soda process from *Themeda cymbaria* Hack.

2. The average fibre length of this grass is 1·08 mm. The chemical pulp from this grass, therefore, requires to be admixed with a long-fibred pulp such as bamboo pulp for the production of good quality writing and printing papers.

Thanks are due to the Botanist of this Institute for the identification of this grass and for his help in writing the section on the botanical description of *Themeda cymbaria* Hack. Thanks are also given to the Government of Hyderabad for the award of a scholarship to one of us (S. C. Asthana) which enabled him to receive training in Pulp and Paper Technology in this Branch and to take part in this investigation.

F.R.I. – DIAPER

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The utilization of wood waste occurring in sawmills and plywood industries is a matter of consideration to the timber industry Marquetry, fretwork, inlay work and carving which have been in vogue for quite a long time are tedious and laborious and hence costly. They do not help a solution of this problem.

Waste increases and accumulates with the thriving of timber industries. Some experiments were carried out by the author to see to what extent this wood waste could be made use of to serve the human needs.

A simple method of gluing the chips and veneers of different colours was adopted to make the F.R.I.—Diaper.

Nature provides a vast variety of natural wood colours and if these coloured woods either in the form of veneers, chips or blocks are blended, they can give us charming varieties of articles in furniture, tiles, etc. At times it becomes difficult to get wood of a particular colour. In such cases any ordinary wood, preferably of a light pale colour can be stained, cured and then used (the method will be explained in the next article).

In this paper, use of two kinds of wood, one being mango and the other *sissoo* is explained. Mango and *sissoo* veneers of 1/16th and 1/40th of an inch are used in the first instance. The veneers are soaked in water for some time until the wood get softened and the veneers can be easily bent to any form. The water-soaked veneers are placed in-between the two parts of the unique-mould under some pressure which gives them the desired shape and also removes the water absorbed by the wood. The type of mould used is illustrated in Fig. 1. The two halves of the mould are of the same pattern and hence the name "unique-mould".

After a day or two the veneers shaped in the mould are painted with a common casein fluoride glue. The mango and *sissoo* veneers are placed one over the other in the order required to obtain the desired design or pattern. The whole block is placed in-between the two halves of the unique-mould and kept under a pressure of about 200 pounds per square inch for about 36 to 48 hours. The laminated, corrugated block is then removed from the press and the mould is stacked in the open to dry and obtain stability under normal atmospheric conditions. This takes a couple of days depending upon the nature of the block and the actual atmospheric conditions.

After the block or cake is conditioned it is planed on all sides so as to get a regular shape free from grooves or corrugations, but in the body of the block a simple wave-like structure is visible, which, in fact, is the first stage in the preparation of further fine patterns.

This block has different patterns on two sides one on which the pattern is wavy as stated above, and another which, after planing to remove grooves, etc., can be used for the outer-face of any box or for decorative panelling.

The conditioned block is held in a vice with the chain structure uppermost and sawn along the grain into veneers of 1/16th or 1/8th of an inch thickness. These veneers are then arranged in reversed directions (180°) and again glued with the same cold setting casein fluoride glue and subjected to a pressure of about 200 pounds per square inch when they will form a chain pattern design as shown in Fig. 2.

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* Communicated by Shri L. Simon, C.R.O., Service Branch, F.R.I.

To make use of this chain pattern one has to cut across the grain, with the help of a saw, sheets of thickness varying from say 1/32nd to 1/8th of an inch ; the sawn veneers are pasted on the sheet of plywood or on the top of a plank of wood with the same cold setting glue. One may use tiny nails to make the thing more lasting and *pucca*.

This is not the end of this block and this chain pattern can yield more designs. One can get intermingled chain designs too. The chain pattern design shown in Fig. 2 above is cut into 1 or 2 inch pieces on the design side at an angle of 45°, and these pieces are again glued together to form a new design known as 'intermingled chain design' (Fig. 3.). Similarly, slices of various thickness can be cut and fixed on tables, boxes, etc. Thus, more and more designs can be developed from this two veneered block with a little imagination or by using a mirror. The mirror is very useful for evolving patterns, because, when placed on the pattern at various angles the mirror exhibits new forms, and the worker can thus cut the block at these particular points indicated by the mirror and join the cut portions for getting different patterns.

If simple and plain designs are required for border purposes or for the outer-face of boxes or some such purpose a laminated block of different coloured veneers is made by applying glue and pressure to straight veneers without causing any corrugations. The unique-mould is not required for this. From this block veneers are cut and used for straight line borders.

The same block can also be used for evolving designs by cutting it along the grain at certain angles and joining the pieces in the reverse direction to form a composite block. This process gives other designs. The composite block can be cut again into strips on the design side, and rejoined in the reverse direction when it gives square or rhomboidal patterns, depending on the angle of the cut.

Walls and flooring of rooms, halls, saloons, etc., can well be decorated with this sort of diaper work either in sliced form glued to the wall or in block form. The latter would serve the purpose of tiles. If, owing to wear and tear or atmospheric influences the polish of the diaper should fade, this can be renewed by planing and repolishing the surface with wax. Thus the workmanship could be kept spick and span for a long time until the blocks or slices get completely worn out.

Diaper work can easily be done on a commercial scale. It requires no elaborate or additional machinery because plywood factories in which abundance of waste material which is needed for diaper work is available, are already well equipped with peeling lathes, veneer-clippers, veneer dryers, cold or hot presses and the like. The only important additional equipment required is the unique mould described above. This is not an elaborate thing as can be seen from Fig. 1. So far as cost is concerned it will be well within the reach of an ordinary man.

It can be seen that diaper is superior to 'marquetry' or 'inlay' work and also helps in utilizing the wood waste of plywood factories and sawmills. Diaper is also useful in decorating drawing-rooms, saloons, furniture, etc., with its large number of patterns that please the human eye. The potentialities of the diaper in the manufacture of attractive articles fit or the export market may well be an additional reason for manufacturing diaper on a large scale.

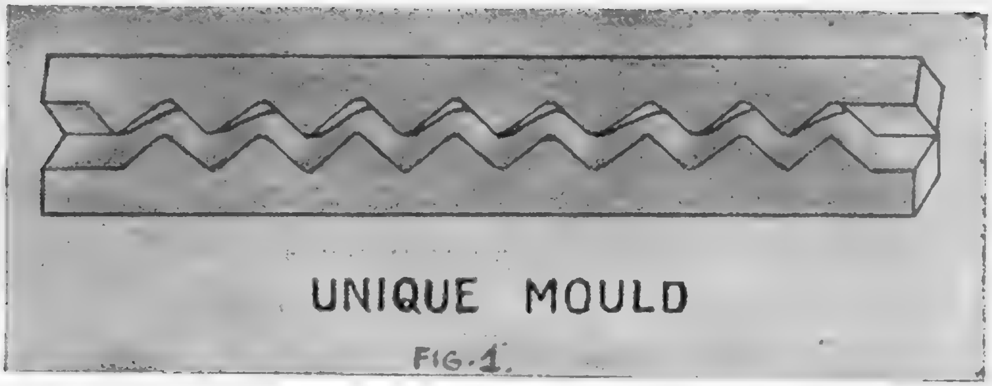

FIG. 1.

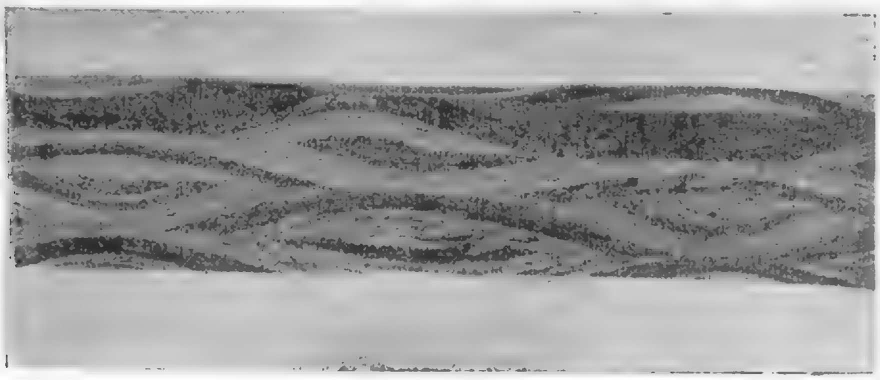
FIG. 2


FIG. 3

PROTECTION OF INDIGENOUS BUTTON NUTS AGAINST INSECT ATTACK

BY M. C. TEWARI
Wood Preservation Branch, Forest Research Institute, Dehra Dun

Apart from bone and synthetic materials, buttons are made from several species of nuts and shells. Generally imported Dome nuts* (*Hyphaene thebaica*) and local coconut shells are used for this purpose by the indigenous industry. There are a few other nuts like the Palm nuts, Talipot nuts (*Corypha umbraculifera*) which can be used as substitutes to imported dome nuts, specially in the manufacture of buttons of small size. It is reported by the Director of Industries, PEPSU, Patiala, that Tar nuts, or Talipot nuts or Tad nuts (*Corypha umbraculifera*) were found to be quite suitable by the local button and bead industry but that they were prone to insect attack. The problem of protecting these nuts against insect attack was, therefore, referred to this Branch. This note gives details of the experiments conducted and recommendations made for a simple and cheap chemical treatment that can be adopted in this connection.

In the first instance dry nuts were obtained and impregnated with Ascu under pressure of 150 lb./sq. in. and with boric acid by the hot and cold process. The penetration of the preservatives was very superficial indicating that the dry nuts are very refractory to impregnation even under pressure. It was then decided to obtain green nuts and treat them by the diffusion process. For this purpose about 20 nuts were kept soaked in separate beakers containing (1) boric acid 3% (2) zinc chloride 5% (acidulated with HCl to pH of 4·5) and (3) copper sulphate 5%, in water solution. After 15 days the seeds were taken out and representative samples from each treatment were examined for depth of penetration and absorption per c. ft. of the preservative. The penetration was found to be complete. Table No. 1 gives details on the absorption of the preservative.

TABLE No. 1

Serial No.	Preservative chemical used and its concentration	Absorption of preservative (dry chemical in lb./c. ft.)		REMARKS
1	Boric acid 3% ..	Outer Inner	3·06 1·50	The treatment was carried out at room temperature, i.e., at about 25°C. For purposes of analysis of the preservative each seed was divided into equal parts, the inner and the outer shells.
2	Zinc chloride 5% ..	Outer Inner	2·28 1·37	
3	Copper sulphate 5%	Outer Inner	3·01 3·62	

Since protection only against insect attack is required, treatment with boric acid or zinc chloride is recommended. Generally a mixture of boric acid and borax in equal proportions gives better protection than either of the chemicals alone. An absorption of 0·5 lb. of the above mentioned chemicals per c. ft. is considered adequate. It is, therefore, recommended to use either 0·5 per cent (0·25 boric acid, 0·25 per cent borax) boric acid-borax mixture or 0·6 per cent of zinc chloride in water solution.

* Note by R. L. Badhwar, Officer-in-Charge, Minor Forest Products Branch, Forest Research Institute.

The Forest Utilization Officer, Bombay, reports that the cost of raw nuts is Re. 1 per lb. and that of manufactured beads and buttons is As. 3 and 1·5 respectively; that they are polished by a leaf obtained locally, that the seeds are collected from the Gundabala Round of Honavar Range in Kanara Division and that the nuts are not edible. The cost of chemicals required for the treatment at 0·5 lb. c. ft. absorption is given below :—

TABLE NO. II

Cost per c. ft. of*

Raw nuts	Beads or Buttons	Chemicals required for preservative treatment	
		Zinc chloride	Borax Boric acid mixture 1 : 1
Rs. 100	Rs. 380	Rs. 0-6-6	Rs. 0-2-6

* 1 c. ft. contains 1900 doz. raw beads or 3800 doz. buttons.

It will be seen that with a very insignificant amount in expenditure the beads and buttons can be protected from insect attack. It is best that the nuts for beads are bored through and for buttons split into two halves before chemical treatment is given so that the preservative may thoroughly penetrate into the material. For treatment with borax – boric acid, copper or brass vessels should be used.

The author expresses his grateful thanks to Dr. A. Purushotham, Officer-in-Charge, Wood Preservation Branch for suggesting the problem and for guidance throughout this investigation.

PLATE I.—The guide is standing near the abnormal tree while a normal sal tree is seen on the other extreme side. The tree in the middle is some other species.

PLATE II

Leaf from a normal tree.

Leaf from an abnormal tree.

SCIENCE NOTES

The Deformed Leaves in Sal

BY S. D. N. TIWARI, F.B.S., S.F.S.
Working Plan Officer, North Bastar Division (Madhya Pradesh)

When I was stockmapping the area along the Southern boundary of Kheksi–Kachhar Reserve, Narainpur Range, North Bastar Division, my guide suddenly jumped away from the forest patch situated along the boundary line. I thought he had gone for privacy in the usual way, but then after going some distance he called out : "Sir, what is this tree ?" I could understand that there must be something peculiar with the tree and therefore, cautiously I replied, "It looks like mango." "No Sir, please see it carefully," he replied triumphantly.

It was a peculiar tree with the stem like sal but with very narrow and drooping leaves. On closer examination it was not difficult to identify it as a sal tree. In the picture the tree on the extreme right is easily marked out from the normal sal tree which is seen on the left. The leaf margin is wavy and cartilagenous and appears to have been cut along the margin but no insect attack was observed. The guide also informed me that the leaves, young or old, are always narrow and this can be seen at the time of renewal of foliage. A sketch of a normal and an abnormal leaf has been reproduced here. There is hardly any change in the appearance and colour of the bark of trees with the normal compared to this tree with its abnormal leaves.

This is the only tree of its kind I have ever seen in the Sal forests of North Bastar and Mandla Divisions. According to my guide, there is one more small sapling about a mile from the above spot but he was unable to locate it now. Shri K. Y. Rao, D.F.O., South Bastar Division informs me that he was also shown one such tree in the Nistari forest of Mutanpal Gidam Range. There the tree is about 4 feet to 5 feet in girth and I have requested him to collect its seeds. It may be worthwhile to study its seedlings.

As far as I could judge on the spot this deformity may be due to some virus disease, and more work on the subject will be very interesting.

The multiple seeded rice of India

BY N. P. CHOWDHURY

This interesting paddy has been designated *Oryza plena* (Prain) Chowdhury Stat. Nov. *O. sativa* Linn. var. *plena* (Prain) [Bengal Plants, Vol. II, p. 1184 (2566/3), 1903].

For a full discussion on the present species see 'A note on the multiple seeded rice of India', by the present author (Ind. For., 75, No. 12, pp. 494–499, December, 1949). The author is thankful to Dr. H. Santapau of St. Xavier's College, Bombay for kindly suggesting this rejoinder in view of article 42 of the latest International Code of Botanical Nomenclature.

DIMORPHISM IN LAC INSECTS

BY P. S. NEGI

Officiating Director, Indian Lac Research Institute, Namkum, Ranchi

The existence of dimorphism, viz., the red and yellow varieties, among lac insects was first recorded in the nineteenth centuary. Mahdihassan[1], while listing the complete literature on this subject, refers to the writer's earlier communication[2] and to the omission of classifying the two dimorphous varieties. He has also expressed doubts about the possibility of the two varieties breeding true to type. The following pages describe in detail the observations the writer has so far carried out in this problem.

Classification of lac insects—Lac is a commercial commodity of great importance. To have a correct knowledge of identity and performance of the different species of the lac insects reported to be occurring a detailed study and a thorough re-examination is necessary. More so in the case of Indian lac insects which contribute the bulk of world produce of lac. Designating different species on superficial and easily variable characters causes confusion.

The growth and form of individual lac insects growing on the same branch and even on the same twig of every host differ greatly from season to season and crop to crop. This point was brought out and illustrated by me[3] and rightly emphasized by Glover[4] in his book under the heading species of lac insects.

It is also a well known fact that there are difference in colour indices, etc., of lac produced even by the same insect on the same host in different climatic and other natural conditions.

The *Shorea talura* broodlac, having three life cycles on *Shorea talura* in thirteen months in Mysore, has only two life cycles on the same host in Ranchi. This difference seems to be due to different climatic conditions and other natural factors in the two areas. The lac insect on *kusum* (*Schleichera oleosa*) in Bihar completes its two life cycles, one in January–February and the other in June–July but the same *kusum* broodlac from Bihar on *kusum* has no definite life cycle periods in the Vannathiparai forest in Mathurai district of Madras from 1932 to this day and has been completing its life cycles in different months in each crop in every succeeding year[6] due to equable climatic conditions in that area.

Hence colour, superficial characters subject to change in different climatic conditions and the growth and formation of lac encrustation on different kinds of hosts under different climatic and physical conditions do not seem to form a reliable guide for the classification of the lac insects.

Experiments on yellow and red lac insects—The crimson and yellow forms of lac insects were obtained from Jodhpur on *ber* (*Zizyphus mauritiana*) and from Jammu Kashmir on *khair* (*Accacia catechu*). The supply from Jodhpur was received in June and November 1927 and from Kashmir in December 1932. However, detailed investigations could be taken up systematically under field conditions only in 1934 when two suitable brass wire-net cages were made available to avoid interference from lac grown in the surroundings. One of these cages was used to study parthenogenesis in the lac insects and the other to study the yellow forms of the lac insects.

In the laboratory, counts of eggs laid by the females and of the larvae emerged were daily done under the binocular microscope. In the field, individual female lac insects ready to give rise lac larvae were placed in small wire-net cages and tied on to twigs of the *caged tree* to rear the progeny ; care being taken that the progeny of one female did not mix with that of

the other. On some branches in certain crops collective infection from two or more females was also studied. Individual females, under study in the laboratory and field after completing egg laying and after emerging out of lac larvae, were examined in the laboratory and undelivered mature eggs left in their ovaries were counted.

COUNTS OF EGGS AND LARVAE IN THE PROGENY OF JODHPUR BER RED AND YELLOW FORMS OF FEMALES

	Red		Yellow	
	Fertilized	Asexually developed	Fertilized	Asexually developed
No. of generations for which observations taken	5	17	6	11
Total No. of healthy females under observations	34	79	40	30
No. of red eggs delivered ..	14,530	37,483	Nil	Nil
No. of yellow eggs delivered ..	Nil	Nil	20,177	14,542
No. of mature red eggs left undelivered in overies	3,984	3,171	Nil	Nil
No. of mature yellow eggs left undelivered in ovaries	Nil	Nil	3,477	1,024

In the progeny of Kashmir *khair* red and yellow lac insects, observations were taken only on two generations of fertilized red and yellow females. Six healthy red females laid 2,647 eggs and they were all red ; in the ovaries 426 mature eggs were left undelivered and they too were all red. Seven healthy yellow females laid 2,939 eggs and they were all yellow ; in the ovaries 600 mature undelivered eggs were left and they too were all yellow.

The above results show that each red female produces only red eggs, and the larvae that hatch are also red. The yellow females produce only yellow eggs and larvae that emerge are also yellow. In other words the colour of the new born young is the same as that of their mother.

II. STUDIES IN FIELD

The experiments were conducted on *ber* and *khair* trees. The former proved a more convenient and a better host than the latter.

From 1928 to 1932, in each crop mass infections of yellow lac females of Jodhpur *ber* and their progeny were conducted. It was observed that during development on the tree a good number of yellow larvae changed into red. The change in colour occurred during the larval instars. The predators and parasites also interferred. Cloth cage for the trees did not prove satisfactory.

Hence from July 1934 experiments were conducted in each crop on one tree under a 80 mesh brass wire-net cage and a limited number (3–9) of yellow female cells of the progeny of Kashmir *khair* broodlac were used.

Here again for the first three generations some yellow larvae changed into red during different larval instars. As many as 57% yellow larvae of the first generations changed

into red. The change was in the males as well as in the females. However, in the fourth generation there was no change in colour at any stage and all the insects retained their yellow colour. But in the fifth generation once again 4·6 per cent yellows changed into red; the red males were destroyed in the third instar. In the sixth generation there was no change in colour all were yellow but in the seventh generation 1·3 per cent changed into red; the red males were again destroyed in the third instar and at crop maturity only yellow females were found living. To grow the eighth generation the selected 5 mothers failed to give birth to young.

In July 1938, the experiments were restarted with 5 yellow females of Jodhpur *ber* progeny selected from the seventeenth generation of asexually bred females. Each mother cell was tied on to a different branch of the *ber* tree. Here again in the progeny of two females during development there was change in colour from yellow to red in some larvae but not in the case of the other three females. In the second generation there was no change in colour in the larval stages, however, some gravid females changed to red but they did not live to maturity. In the succeeding three generations the progeny was all yellow. Further experiments had to be stopped due to change in programme.

Some other instances of occurrence of red and yellow lac insects—In several seasons even in the Namkum Plantation, here and there yellow lac insects have been found amidst the red insects in *rangeeni* as well as in *kusmi* lac. In August 1935 in the Katki crop yellow lac cells were found in the progeny of *palas* (*Butea monosperma*) lac on *khair*, and in February 1936 in the progeny of *kusum* (*S. oleosa*) lac on *khair* in the *Aghani* 1935–36 (June to February) crop. In December 1942, in village Jamla of Chota-Udepur, I found yellow and red lac insects in the *Baisakhi* 1949–50 crop on *Ficus infectoria* locally called *pipli*. The villagers told me that the yellow insects change to red when the crop matures, this statement is in accord with my observations recorded earlier. In April 1950 in Pawagarh near Halol, Panchmahal Forest Division, Bombay, I found red and yellow lac on *ber* in the *Baisakhi* 1949–50 crop. In December 1950 I came across red and yellow lac insects on *pipal* (*F. religiosa*) in Avad Forest Division, U.P. In March 1953, I found red and yellow lac naturally growing on *Ficus religiosa* trees in the compound of the Banaras Hindu University. There was no lac anywhere in the area when I left the University in 1925. In May 1953, Shri J. N. Singh of this Institute collected red and yellow lac insects naturally growing on *pipal* (*F. religiosa*) from Monghyr, Bihar. It was from Monghyr that Mr. E. E. Green received his samples of *L. fici*. In June 1953, Shri Shyam Deogam brought some samples of *palas* lac from Konai near Panki in Palamau, Bihar and in one stick about nine inches long two mature yellow females were found at two different places amidst closely encrusted red females. In the same month, among samples received through Shri M. M. Srinivasan, Special Officer for Lac Cultivation, one stick of *palas* lac about six inches long from Shadol Range, Vindhya Pradesh was found to have a thick encrustations by pure yellow nearly mature female insects, while in another two bundles measuring a total length of about eight feet, received from Devacad-Baria, Poona Forest Division, Bombay, dead and parasitised closely set immature yellow insects intermingled with the red variety were also observed.

Conclusion—I could not complete the study of the problem but from whatever experience I have of the two forms, it is clear that crimson mothers give rise to crimson larvae and the yellow mothers to yellow, i.e., both breed young ones of their respective colours. It is during their growth on the tree that some of the yellow larvae change into red. However, I have not actually seen any red larva changing into yellow. A critical study on change of colour in red larvae in the field has also not been carried out. But instances of the presence of yellow females among reds observed in *palas* and *kusum* brood on *khair* at Namkum in *palas* brood at Panki do indicate this possibility also.

This difference in colour between the two forms may possibly be due to one of the following two reasons : (i) the colouring matter in the two may be chemically different and the yellow variety being biologically convertible into reddish one, or (ii) the colouring matter in the two may be chemically the same but may be present in different amounts in concentrations, so that when present in traces only it appears to be yellow whereas when present in sufficient quantity it appears to be red. A possible support for the latter view is available from the fact that both the colouring matters of yellow and of crimson insects give with alkali the same pinkish shade. However, there is room to suspect that there may be true mutents in some of the yellow forms and to discover this aspect a study of chromosomes in the two forms would be necessary. As sufficient quantity of sticklac produced by the yellow females could not be collected, chemical tests on the comparative qualities of lac produced by the two forms could not be arranged.

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INSECTS AND OTHER WILD ANIMALS AS HUMAN FOOD

BY R. N. MATHUR, M.Sc., Ph.D., F.E.S.I., F.R.E.S.
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Tastes in foods are generally a matter of style or popular fancy. Mankind eats many curious things and the meat of several kinds of animals, from crocodiles to snails, are delicacies to him but there is an absurd prejudice against insects, particularly among the civilized people. Some persons abhor insects and fear prevents our making use of them for human consumption. As articles of human food, some insects are important sources of essential dietary elements. In some countries like Australia, Africa, Asia and the Americas, the insects are consumed along with apples, spinach or other food either as tid-bits or as more or less staple diet by various peoples. Bristowe (1932) writes, "the Samoans catch Palolo worms (*Eunice viridis*) at their biennial swarming periods, natives of all countries where locusts abound collect them for food, scarabs are eaten by the Bedouins, cockroaches and silkworm chrysalids by the Chinese, spiders by the Lepchas of India, termites and certain larvae by the Javanese, water-bugs by the Mexicans, cockchafers by the Italian peasants and, unwittingly, the British eat cochineal insects and cheese mites". Sometimes the insects and other invertebrates are eaten in great quantities at the particular season in which these species occur in abundance. According to Bodenheimer (1951), the insects are highly nutritious and they can provide astonishing quantities of proteins, fats, vitamins, salts and minerals. He has discussed the various insects eaten in some countries and the methods of collecting and storing these insects. Bristowe (1932), Bruce (1946) and Hoffmann (1947) have also published information on insects used as human food. Unfortunately, accurate information about insects, taken as food by man in India is not available except the brief notes published by some of these authors. Examples of Indian species of insects are cited below. For wild animals as food, the books published by Prater (1947) and Salim Ali (1946) have been consulted.

I have dealt with this aspect rather lightly because of lack of knowledge, and therefore, forest officers and other readers are invited to give authentic data regarding the methods of collecting, cooking, etc., and the species of insects or other invertebrates consumed as food.

For determination of the species, some examples may be sent to this Institute.

Insects as Food

BEETLES

1. The plump and fatty larvae of several kinds of Longicorns and Buprestids (wood borers) are extracted and roasted for food by Laos in Siam.

2. The scarab larvae of *Adoretus* spp. (Fig. 20), (injurious to rootlets of plants), *Oryctes rhinoceros* Linn. (Fig. 7), (a pest of coconut and other palms), *Xylotrupes gideon* Linn. (Fig. 17), (develops in manure heaps and rooted vegetable matter in soil) are roasted with salt by Laos in Siam and Bedouins in Egypt. The beetles of *Oryctes* are also roasted or fried and are greatly prized by Laos natives.

3. The weevil larvae (Fig. 18) of *Rhynchophorus ferrugineus* Oliv. (pest of coconut and palms), *Crytotrachelus longipes* Fabr. (Fig. 19), and *C. dux* Boh. (borers of young sprouting bamboos) are extracted and roasted or fried for food in Siam and also in India.

4. The white plump weevil larvae (Fig. 16) of *Protocerius fervidus* Pascoe (Curculionidae) are eaten by the Murias of Bastar State (Tiwari, 1954). They are collected from the bulbous stem of *Phoenix acaulis* and are eaten as raw or fried in *Mohwa* oil and taken with rice.

5. The water beetles (Dytiscidae and Hydrophilidae) are eaten both as medicine and as confection. In Burma, *Eretes* (*Eunectes*) *sticticus* Linn. (Fig. 10) is eaten both in the adult and immature stages and is considered a delicacy by the Burmese. This species is also quite common in India. Several species of *Cybister* (Fig. 8) and *Hydrous* (Fig. 9) are used as food in China, Tibet, Indo-China, and Hainan Island. These insects are collected by nets and prepared by dropping into hot brine or are roasted. The chitinous parts, elytra and legs are discarded when eating.

BUGS

A few species of stink-bugs (Pentatomidae) and water-bugs (Belostomidae) are eaten in India, China and Siam. One species of Cicadidae is also an article of diet among the Siamese.

1. *Coridius* (*Aspongopus*) *chinensis* (Dallas) (Pentatomidae).—Occurs in Bhutan, Assam, India and China. This species is eaten by the tribes in Assam. In China, this bug is on sale at the Chemists' shop and is commonly used in an aphrodisiacal medicine.

2. *Coridius* (*Aspongopus*) *nepalensis* (Westw.) (Pentatomidae).—It is found in Assam, Nepal and Sikkim and is used as food by the natives of Assam, pounded with rice. This bug gives a powerful aromatic flavour to the rice.

3. *Cyclopelta subhimalayensis* Strickland (Pentatomidae) is fairly common in Assam and is eaten with rice by the Assamese.

4. *Erthesina fullo* Thunb. (Fig. 11) (Pentatomidae) is widely distributed in India and is eaten by the Nagas in Assam. It is very variable in colouration, and feeds on the trunks of many species of trees.

5. *Lethocerus* (*Belostoma*) *indicus* Lep. et Serv. (Belostomidae) (Fig. 1) is widely distributed in the Oriental Region. This giant water-bug is caught by water nets and requires to be handled with great care as its puncture is poisonous and painful. These bugs are cooked by dropping them into boiling water containing a little salt. They are also cooked, dried and powdered to add piquancy for curries or sauces, and are considered as a great delicacy by Laos and Siamese. They are also served on the tables of princes in Bangkok. These bugs are sold in small bottles in the cities like Canton, Hong Kong, Shanghai and Singapore. The bugs are attracted at light.

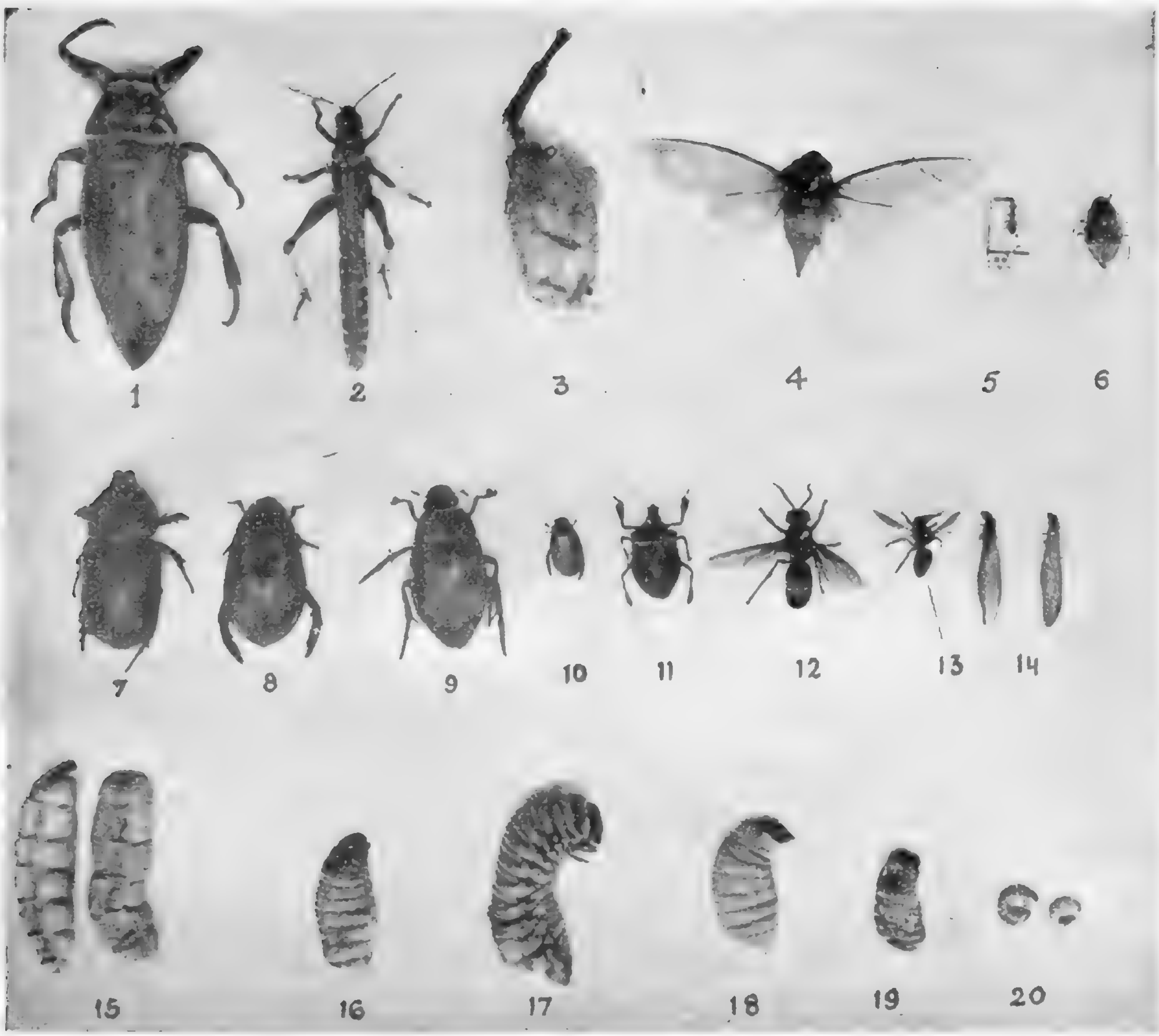
6. Two species of *Sphaerodema* (Belostomidae), *S. rustica* Fabr. (Fig. 6), and *S. molestum* Duf., are small flat greenish water-bugs common in India and Siam. They are eaten with great relish.

7. *Dundubia intemerata* Walk. (Cicadidae) (Fig. 4) is found in Assam, Malay Peninsula and South Siam. They are collected at certain seasons by clapping hands in unison or bamboo pieces together near a lighted fire during dark nights. These insects are highly prized by the Laos.

GRASSHOPPERS AND CRICKETS

Some species of grasshoppers and locusts *Patanga succincta* L., and *Schistocerca gregaria* Forsk. (Fig. 2) are taken as food on account of their large size and frequent availability in considerable numbers, since very early times. They are roasted and eaten in Africa, Arabia, Siam and India. These insects contain a good quantity of animal proteins. They are cooked in different methods by various people.

Among the crickets, *Gryllus testaceous* Walck, *Brachytrypes portentosus* Licht, and *Liogryllus bimaculatus* de Geer are roasted and eaten. These insects live in burrows in the soil.



Insects used as Human Food.

Photo by R. N. Mathur.

TERMITES (White ants)

White ants are considered to be rich in fats, proteins, phosphates and potash (Bodenheimer, 1951). Lapage (1952) has reviewed from Bodenheimer that "one analysis of white ants (termites) shows a content of 44·4 per cent of fat and 36 per cent protein ; 100 *g* of them provide 561 calories, so that they are among the richest foods and superior to some other animal foods". Termite queens (Fig. 15) are roasted or fried in fat and are eaten as a delicious dish by some tribes in India, Africa, Siam and in other countries. Winged termites (Fig. 14) are caught in large numbers at the swarming periods and when their wings drop off, they are roasted with salt. In Africa, they are sold as dried termites for food.

ANTS, BEES AND WASPS

The red ant, *Oecophylla smaragdina* Fabr. (Formicidae) (Fig. 5) is found throughout India, Burma, Malaya and Siam. The ants are rusty red of medium size and construct a nest of leaves bound together with silk, on trees. They possess long and formidable mandibles and inflict their sharp bites if interfered. In Burma and Siam this ant is reported to be a delicacy. A paste made of ants is eaten as a condiment with curry.

It is said to be a common practice among the tribes of India to feast on the honey, larvae and pupae of the rock bee, *Apis dorsata* Fabr., (Apidae) (Fig. 13) found in the combs. Its large comb is found suspended on the face of precipitous rocks, cliffs, etc., or to the larger branches of tall trees. The bees are driven off by fire and smoke. This bee is easily irritated and readily attacks man, sometimes with fatal results. The honey and grubs of *Apis indica* Fabr., are also eaten.

The grubs and adults of *Vespa cincta* Fabr., (Vespidae) (Fig. 12) are eaten in Siam. This hornet has a broad orange stripe on abdomen and is found generally in thick forest, throughout India, Burma, Tenasserim, Siam. It makes its nest in the hollows of big forest trees. The wasps are destroyed by fire and smoke. Both the adults and grubs are fried with a little salt, the legs and heads are discarded while eating.

The grubs of *Eumenes petiolata* Fabr. (Eumenidae) are fried for food. This species is common in houses and makes its mud cells on walls, window frames, floors, etc. A nest may contain seven to ten cells which are stocked with paralized caterpillars. The grubs of this wasp feed on these caterpillars.

The underside of the abdomen of carpenter bees – *Xylocopa latipes* Drury (Apidae) is eaten raw by the Laos. This bee is large, purplish black with dark wings, and makes its nest in posts and beams.

MOTHS

In some parts of India and China, wild silkworm (*Antheraea paphia* Linn.) (Fig. 3), pupae are regarded as a delicacy and are extensively eaten when the silk has been reeled off. The pupae are either cooked in very hot water or roasted. These silkworm species occur commonly in Assam, Bengal, Kashmir and other parts of India. The larvae of the coffee-borer (*Zeuzera coffeae* Nietn.) (Cossidae) are also used for food. The Siamese roast them and eat with salt and rice. This species is a serious pest of tea and coffee growing areas in India and Ceylon, and frequently it attacks yearlings and small saplings in forest nurseries of *Casuarina*, *Santalum*, *Swietenia* and *Tectona*.

FLIES

The maggots of *Chrysomyia megacephala* (Fabr.) (Green bottle fly) (Calliphorinae) are sold as dried larvae for medicine and food in Canton (China). This species is widely distributed in India, Oriental and Australian regions. It breeds mainly in decomposing animal matter.

Wild Mammals as Food

Wild life is very valuable to the country because several species are of prime importance for food. The even-toed ungulates are the chief source of meat. They feed on vegetation. A few rodents are also important meat animals in various parts of India. These animals are now protected by laws. There are close seasons, bag limits, game and bird sanctuaries designed to protect all the valuable useful species. All hunters, sportsmen and campers are required to possess a certain knowledge of the wild life, of the close season for each species of game and of the places where hunting is prohibited.

Among the ungulates which furnish meat for man in the forests, are the following species :—

(1) *Rhinoceros* spp. (Rhinoceros)—Found in the terai of the Himalayas, from Bhutan to Nepal. Frequent swampy ground in forests and dense jungles. At times, they are furious and attack man. In Nepal, its flesh and blood are considered highly acceptable to the *manes*. Prater (1947) writes that high caste Hindus and most Gurkhas offer libation of the animal's blood after entering its disembowelled body.

(2) *Sus* spp. (Wild pigs)—Widely distributed. Live in long grass or bush jungles or forest. They seldom attack people except when scared or wounded.

(3) *Cervus* spp. (Deer), *Rusa* spp. (Sambar), *Axis* sp. (Chital), *Muntiacus muntjak* Zimm. (Barking deer), *Moschus moschiferous* L. (Musk deer). They are inhabitants of forests or grass jungles and remain in small herds.

(4) *Boselapus tragocamelus* Pall. (Nil-gai)—Found throughout India, from the base of Himalayas. It frequents thin forests and low jungles.

(5) *Nemorhadus* spp. (Goral)—Inhabit the wooded mountains of the central ranges of the Himalayas, from Kashmir to Sikkim. They feed on rugged grassy hill-sides or rocky ground in the midst of forests.

(6) *Hemitragus jemlahicus* (H. Sm.) (The Himalayan Tahr or wild goat)—Throughout the Himalayas from the Pir Panjal to Sikkim. Their favourite habitat is a precipitous terrain of towering cliffs, rocks, dense scrub and forest. They live in herds.

(7) *Ovis* spp. (Wild Sheep)—Found from Sikkim to Simla. More abundant in Kumaon and Garhwal. Found at great elevations, from the limits of forest to the extreme limits upwards of vegetation. They associate in flocks.

(8) *Bibos gaurus* H. Smith (The Gaur)—The Gaurs are found in the hill forests and associate in herds. They are timid by nature and avoid man. A wounded gaur may charge, and a solitary bull may attack without provocation.

(9) *Bubalus bubalis* L. (The wild buffalo)—Found in the grassy jungles of the Nepal Terai, the plains of the Ganges and Brahmaputra in Assam, and in parts of Orissa and Madhya Pradesh. They are described as being the boldest

and most savage of the Indian Bovidae. A bull may attack without provocation. A cow with a new.y born calf is dangerous.

In the Edentata, the flesh of *Manis aurita* (the Chinese pangolin) is said to be excellent and is eaten by some of the hill tribes. They are known as scaly ant-eaters and range westwards through Assam and the Eastern Himalayas to Nepal.

Among the Rodentia, *Canomys badius* Hodgson (the bay bamboo rat) is eaten by the hill tribes. Occurs from the base of the Himalayas in Nepal through Sikkim and Bhutan to the Assam Hill Ranges. These rats feed on young grass, leaves and on roots. Their movements are slow, and their sight weak permitting of easy capture. But they bite fiercely.

A species of porcupine, *Hystrix hodgsoni* Gray is found in the Central and Eastern Himalayas, Assam and Lower Bengal. Feeds on tuberous or edible rooted crops. Its flesh is delicious and is eaten by all tribes and classes. It is easily tamed and bred in confinement.

Practically all species of hares and rabbits (*Lepus* spp.) are eaten. They are widely distributed and are important meat animals.

The flesh of the Beasts of Prey and the Carrion-feeders including the tigers, leopards, panthers, cats, wolves, dogs, jackals, foxes, civets, mungooses, hyaenas and bears, is not eaten. The meat of the insectivorous and frugivorous bats is also not taken. Similarly the meat of lemurs and monkeys is not liked, but the Assamese Macaque – *Macaca assamensis* (McClelland) is hunted by the Lepchas for food and the supposed medicinal value of the flesh. The Assamese Macaque is found throughout the ranges of Himalayas, Assam and the forests of the Sunderbans.

Wild Birds as Food

The meat of several species of wild birds is used for food by man. The chief groups of birds of great value as food are the ducks and geese, and the fowl-like birds such as quails, partridges and pheasants, and also doves and pigeons. A few examples are mentioned below :—

Crocopus phaenicopterus (Latham) – (The Green Pigeon),
Columba livia Gmelin – (The Blue Rock Pigeon),
Streptopelia spp. – (doves),
Pavo cristatus L. (The Common peafowl),
Gallus gallus (L.) – (The Jungle fowl),
Coturnix spp. (quails),
Francolinus spp. (partridges),
Rostratula bengalensis (L.) – (The painted snipe), and
Tochus birostris (Scopoli) – (The Common Grey Hornbill).

Other birds, viz., the flesh-eaters, the fish-eaters and the carrion-eaters are considered as non-palatable.

Other Wild Life as Food

Reptilia (Crocodiles, tortoises, lizards and snakes)—An almost universal prejudice persists against the flesh of all reptiles except the turtles. The flesh of turtles furnishes an important diet of fishermen, but for the rest of mankind, their meat serves as an incidental tid-bit.

Amphibia (Toads and frogs)—The principal economic importance of these animals, lies in the frogs because their legs are used for food.

Pisces (Fishes)—Many kinds of freshwater fishes are of great importance and the chief sources of food for man.

Crustacea (Cray-fishes, prawns, lobsters, crabs, shrimps, etc.)—These animals are found in sea or in rivers and are extensively used for food.

Mollusca (Shell-fish, oysters, sea mussels, etc.)—They live in water and are considered delicious food by various people.

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EXPLANATION OF PLATE

FIG. 1. *Lethocerus indicus* Lep. et Serv.
FIG. 2. *Schistocerca gregaria* Forsk.
FIG. 3. Cocoon of *Antheraea paphia* L., containing pupa inside.
FIG. 4. *Dundubia intemerata* Wlk.
FIG. 5. *Oecophylla smaragdina* Fabr.
FIG. 6. *Sphaerodema rustica* Fabr.
FIG. 7. *Oryctes rhinoceros* Linn.
FIG. 8. *Cybister* sp.
FIG. 9. *Hydrous* sp.
FIG. 10. *Eretes sticticus* Linn.
FIG. 11. *Erthesina fullo* Thunb.
FIG. 12. *Vespa cincta* Fabr.
FIG. 13. *Apis dorsata* Fabr.
FIG. 14. Winged termites.
FIG. 15. Termite gueens.
FIG. 16. Larva of *Protecerius fervidus* Pascoe.
FIG. 17. Larva of *Xylotrupes gideon* Linn.
FIG. 18. Larva of *Rhynchophorus ferrugineus* Oliv.
FIG. 19. Larva of *Cyrtotrachelus longipes* Fabr.
FIG. 20. Larvae of *Adoretus* sp.

THE SAPLING BORER OF TEAK

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After the merger of Bastar State in the Indian Union, regular plantations of teak have been started in many parts of the division. In one such plantation of North Kanger Range which was raised about a year ago, a very damaging teak borer attack was discovered. A lot of saw-dust was found at the base of the affected stems. On closer examination a small hole, was found from which the infection had started and the saw-dust was pushed out by the borer was on the ground (Photo No. 1). One such infected plant was uprooted and split through longitudinally (Photo No. 2). The gallery of the larva runs from top to bottom

PHOTO No. 1
Lot of saw-dust is seen at the base of the plant on the ground and a hole on the stem can be spotted a few inches above.
Photo by Author.

PHOTO No. 3
The larva, full size.
Photo by Author.

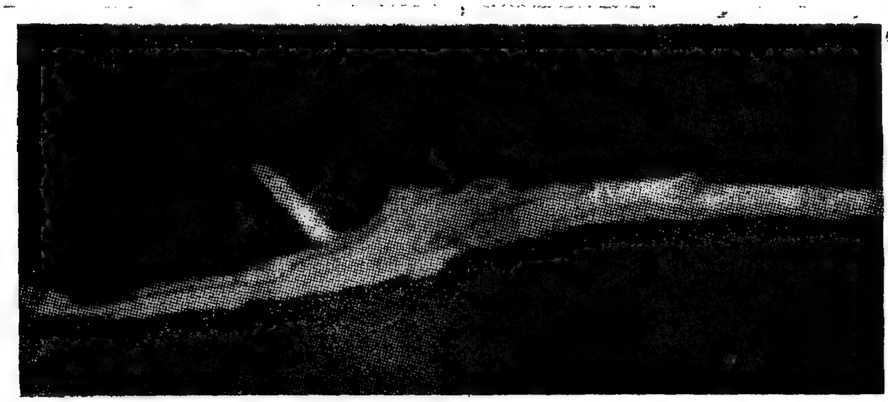

PHOTO No. 2
Longitudinal section of the stem showing the gallery.
Photo by Author.

through the hypocotyl into the root but stops a few inches below the collar. From local enquiry it is learnt that the infection starts sometime at the beginning of winter and the larva reaches its full dimensions by March when it is about an inch to 1½ inches in length (Photo No. 3). Perhaps, it pupates in May and the adult insect emerges out by the beginning of the rains, but a thorough study of its life-cycle has not been possible.

Generally speaking this is one of the most damaging of the borers on teak as, in the plantation referred above, about 5 per cent of the plants were found infected. The same infection was observed in a few nursery saplings brought by the Divisional Forest Officer, North Bastar Division from Sonpur in Narainpur Range. The two areas are situated about 100 miles apart; thus the insect has quite a wide range of distribution. However, it was not noticed by me in the adjoining South Chanda Division. In any case, it is very important that a survey of its distribution should be done as early as possible. The after-effects of the attack have not been studied thoroughly nor a plant with a second attack been found in the older plantations, but no teak plant was seen killed by this attack. It is probable that the plant survives the infection which becomes the starting point for future hollowness of the trees. Thus it reduces the timber out-turn from the trees and the value of the plantation. This may also solve the mystery of the basal hollowness found in mature teak trees which has often been attributed to fire-damage. As far as its control is concerned, the solution should lie in catching and destroying the beetles when they emerge at the beginning of the rains, uprooting the infected plants and destroying the larvae. The attacked plant can hardly be helped as both the root and shoot are bored at their base.

The infected plant and the bottled larva were sent to the Forest Research Institute for identification and it has been identified as *Coelosterna* sp. (*Cerambycidae, Coleoptera*). Further work on the life-histroy of the borer may perhaps provide a clue to the determination of its specific name.

PLANT ECOLOGICAL RESEARCH IN INDIA

BY G. S. PURI

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Plant ecology as a research subject has not featured in the past in the curriculum of many Universities and Research Institutes in India ; as a result of which the development of the subject has sadly lagged behind many less important branches of botany. The importance of ecological knowledge and approach is now keenly felt in many branches of human endeavour. In a number of projects under the Five Year Plan dealing with afforestation and immobilization of deserts, preservation of catchment areas of rivers, creation of shelter belts, soil and water conservation, nature conservancy, amelioration of climatic conditions, flood control, wild life management, etc., trained ecologists are of great assistance. The revival of the Botanical Survey and National Botanical gardens in the near future will need workers for organized ecological studies. The Indian Universities may, therefore, re-orientate their courses, giving proper place to ecological teaching and research, so that trained young men become available for nation-building activities. This question has been recently discussed (Puri, 1953 ; Bose, 1954 ; Puri and Misra, 1954) from the University angle.

The ecological research at some Research Institutes is already receiving a fresh impetus and in professional courses in forestry, special stress is being laid on teaching methods of ecological research, the aims, scope and application of ecology to applied problems. Crop ecology, grassland research and range management offer tremendous opportunities for ecological studies and if the problem of making India self sufficient in food, fodder and fuel is to be solved there is a need for expansion of ecological research in agriculture, soil conservation and pasture management departments as well.

Plant ecology touches upon many related sciences, and ecological literature is so scattered that an average worker in this country is not able to clearly appreciate the importance of this problem. The UNESCO has recently entrusted Dr. R. Misra of the Saugor University and myself for the preparation of bibliography of Plant Ecology in South-East Asian region. In this note it is intended to give a short history of the progress of this science in the country and draw attention to big gaps in our knowledge of the reciprocal relationship of plant life to its environment.

In the development of plant ecological research in India, as also in other countries, three main stages may be recognized. The first period was of general geographical survey of vegetation and broad floristic studies ; which resulted in the preparation of floras, of smaller regions as well as of the whole country. This work, however, is not completed yet and there are large stretches of the country, especially in Alpine Himalays, Eastern Himalayas, and coastal evergreen forests which have yet to be botanically surveyed. Moreover, the nomenclature used in the older floras has greatly changed and needs revision urgently.

Excepting for the flora of British India by Hooker, which has long become out-of-date and needs a revision badly, and those of Collett and Duthie, ground flora species have not been described in many of the regional floras. There is hardly any complete work on Indian mosses and lichens ; though incomplete accounts of some Indian liverworts, ferns, and fern allies have been published.

It may be considered that without complete taxonomic studies, progress in ecological work is almost impossible and the present rudimentary condition of plant ecological research in this country may, perhaps, be partly due to this. Check lists of floras of small areas can,

perhaps be quickly prepared on the lines of the British Ecological Society, which will greatly facilitate ecological studies.

The forests of the Indian region lie scattered roughly between lat. 8°–36° N. and long. 67°–97° E., and present a bewildering variety of vegetation types. This is due to the geographical position of the Indian subcontinent and its long geological history which factors have produced an enormous variety of climatic, physiographic, geological and soil features.

Botanically, India may be divided into three main simple natural regions, namely the Himalayas, the plateau and the alluvial plains. Some workers have preferred to make the Thar Desert (which comes under alluvial plains) as a separate fourth unit. Of these, the plateau represents one of the most ancient parts of the earth and the alluvial plains are the youngest, geologically. The Himalayas which are the loftiest, but still one of the most youthful mountain-chains of the world are mainly Tertiary in age, though bits of older strata and large stretches of secondary deposits belonging to the glacial and post-glacial ages are also found. A well developed sequence of glacial and interglacial deposits is represented in Kashmir ; also in Nepal and the parts adjoining to it in the Eastern Himalayas.

The drainage pattern of Northern India has greatly changed in post-Tertiary times. During the Pliocene and Pleistocene, geographical up-heavals not only dismembered the old SE. to NW. flowing Indo-Siwalik river into three different systems – the Indus, the Ganges and the Brahmaputra – but elevated the Himalayas by more than 6,000–7,000 ft., bringing glaciation in hills and cold conditions to alluvial plains and to much of the Indian Peninsula. These conditions brought about great changes in the vegetation of India and the present discontinuous distribution of many genera and species and the presence of exotic elements in our flora may be related to these changes.

Much of this knowledge is comparatively new, however, early workers (Clarke, 1898 ; Hooker and Thomson, 1855 and Hooker, 1906) divided the country into a number of botanical regions on static features of geography and physiography. Calder (1938) made 6 main botanical divisions of India, namely NW. Himalayas, E. Himalayas, Indus Plain, Gangetic Plain, Deccan and Malabar, while Chatterjee (1938) after taking into account the endemic and exotic elements presented 10 botanical regions, which are similar to Calder's divisions, excepting that Deccan is split into two, and the Himalayas are subdivided into three – NW., Central and Eastern ; and Upper and Lower Burma and Assam are added as three separate units.

In his presidential address to the Botany Section of the 31st Indian Science Congress, Sabnis (1944) reviewed the work of this first stage of ecological research, with special reference to India. He observed that "although the great vegetation zones of the earth have been described, the record is yet very incomplete. In many cases the record deals with the trees and shrubs, but the lesser forms, which nevertheless play big parts in the balance of life, have been left undescribed".

The second stage in the development of forest ecological research in India was concerned with specialized studies of vegetation in relation to one, or the other, of the ecological factors. Inspired by Schimper's and Warming's works, attention was focussed in this country on climatic factors ; and the expansion of the Meteorological Department by about that time provided the much needed data on rainfall and temperature (Blanford, 1889 ; Eliot, 1906). This stimulated studies on correlation of vegetation with altitude, rainfall, aspect and temperature in different regions of the country. The limit and distribution of tropical, subtropical, temperate and Alpine types of vegetation began to be recognized. In these studies, the State Forest Departments made pioneering efforts and led the University men to this science. However, much of the detailed work was done by the latter category of workers,

In the Himalayas, Dudgeon (1920, 1923) recognized three altitudinal zones, viz., Monsoon zone (Tropical) up to 5,000 ft. ; Temperate zone of broad-leaved sclerophyll between 5,000–11,000 ft. ; and Alpine zone of birch-silver fir above 11,000 or 12,000 ft. Kenoyer (1920–22) initiated successional studies of vegetation. A. E. Osmaston (1922) classified temperate forests of the Garhwal Himalayas into a number of forest types, relating these mainly to climate, altitude, and general physiographical features. In his book on Silviculture of Indian trees and later in an article in Tansley and Chipp's book, Troup (1921, 1926) gave an excellent summary of the climatic altitudinal (also some edaphic) relationships of Indian vegetation.

Ecological studies were done after the publication of Troup's work by officers of the Forest Departments and published in departmental journals, chiefly Indian Forester. In the Western Himalayas attempts were also made at the classification of ground flora types in the silver fir and spruce forests of Kulu an chir pine forests of Kangra on the basis of the depth of humus, somewhat on the lines adopted in Northern European countries by Cajander, Muller and Romell.

Some ecological studies on the vegetation of Indian desert (Blatter and Hallberg, 1918 ; and Sabnis, 1921) and Terai and Bhabar (Channer, 1908) was done. In Burma, Stamp (1925) correlated vegetation with geology, soil and climate and attempted a synthesis of all the ecological factors. The aerial survey maps were used for the first time in the study of the ecology of the riverain forests of the Irrawadi Delta.

In Assam, Bor and in Bihar, Orissa and Eastern States, Mooney and in C.P., Hewetson published ecological studies in Indian Forest Records. A great deal of ecological work in the *sal* forests was done by the Forest Departments of the sal-bearing provinces which was summarized by Champion in 1933 in his memoir on the management and regeneration of sal.

Some useful general information on vegetation, climate, geology, soils, etc., of small parts of Indian forests is contained in Forest Working Plans.

During this period work on grassland ecology was mostly concentrated in the Deccan and Bombay areas. There are usefull papers by Garland (1932), Burns, Kulkarni and Godbole (1931). Hole (1911) published ecology of grasses in Dehra Dun forest areas and showed various successional stages on the freshly deposited river alluvia. Some interesting work on the grasses of Madhya Pradesh is being done at Saugor by Misra and Pande.

Ranganathan (1938) wrote a stimulating paper on the ecological status of the sholas and grasslands in the Nilgiris.

The probable effect of the last Ice Age on the origin, distribution and migration of the Himalayan plant communities was studied by Puri (1949–50), who described fossil floras of the Kashmir Himalayas. He described past oak and laurel forests from the northern slopes of the Pir Punjal, where none of these species occur to-day. Oak-conifer and several broad-leaved temperate forest communities are described and ecological conditions under which they had lived during Pleistocene Period are given. This work which is not yet completed, however, brings to light vast changes in altitude, climate and soil in the Himalayas since the Pleistocene.

The reasons for the distribution of the Himalayan species in the hills of South and Central India have been engaging the attention of Indian botanists since long. Royle (1835) explained them to be due to the lowering of temperature by glaciation in the Pleistocene ; but recently much useful information has been added in a symposium on Hora's Satpura hypothesis which envisages the existence during the Pleistocene of a continuous range connecting the E. Himalayas with hills of the Peninsular India through which plants could migrate.

As a result of Raunkiaer's publication of plant life forms and biological spectra, work was done in this country by Bharucha and his students.

During the second period of ecological research in the country much useful work on micro-climatic conditions of crop plants was done by the Agricultural Meteorologist at Poona and a map of India showing Meyer's ratio lines of precipitation/saturation deficit was prepared. This department is extending its activities to both agricultural and forest areas.

As a result of Hans Burger's studies in Switzerland and France of the effects of forests on rainfall, water table and general climate of the area much enthusiasm was created in this country and some work was done.

The evaluation of light factor for crop plants has been done by Dastur (1935) but nothing so far has been attempted for Indian forest species, though, much of the silvicultural operations in the forest are aimed at changing light conditions for the growth of tree seedlings.

A good deal of work on soil conditions of crop plants has been done by the Indian Agricultural Research Institute, New Delhi; Indian Institute of Science, Bangalore; Provincial Agricultural Departments; Irrigation Departments; and the Indian Universities. Officers of the Irrigation Department, Simla especially Hoon, Mehta, Taylor, A. N. Puri and others made useful studies in Kallar and other Punjab soils that belong to the Indus alluvium and the U.P. Soil Laboratories have a comprehensive plan for soil surveys.

The study of forest soils in India is comparatively recent, the only older work being that of Barrington (1930, 1931) for Burma. Admirable studies on soils of conifer forests of Kulu and Kashmir were done by Taylor and his associates. Puri (1950, 1951) has made further contributions to the ecology of forest soils in the conifer and sal forests.

Several articles on the need for a soil survey and soil map of India appeared in Current Science (1936; 1940). The first soil map of India in relation to Mayer's lines was prepared in 1943. This map with the help of geological foundations of the soils of India (Wadia, 1942, 1945) has now been improved and gives a better relationship of soil types with the main climatic features.

The problem of erosion and landslips and their effects on vegetation development has been studied in some detail in the Siwaliks by Gorrie and other officers of Punjab Forest Department. The present position of our knowledge of the erosion problem in the Siwaliks was recently summed up by Puri (1949), stressing the ecological approach to erosion problem.

The other significant contribution of this second phase of ecological research in India was the preparation of climatic forest types map by Champion in 1938, which with the help of the soil map should form a sound basis for the ecological studies of India's vegetation.

Forest types of Champion, though useful in classifying our main forest types, have to be critically examined in relation to all the ecological factors and revised and amplified for applying to problems of economic ecology.

In his Presidential address to the Indian Science Congress in 1937, Champion stressed on this "need for scientific study of India's climax vegetation and observed that 'even in temperate western countries very little is yet known about the physiology of the crops, and the life history and problems of the tropical forests are still almost unexplored. In the absence of needed information, there is a rather dangerous tendency to apply what is known or believed to hold for the temperate forests without proof that such application is permissible".

While some progress on tree physiology and autecology of Indian trees was made (see Troup, *loc. cit.*), a little work on autecology of herbaceous species was done by Misra and his students. Advances, however, were made in agricultural physiology at the Agriculture

Research Institute and the Indian Universities. Special mention may be made of studies of B. N. Singh, his co-workers and students at the Benaras Hindu University and at Lucknow.

About seven years after Champion had delivered his presidential address to the Botany section of the Indian Science Congress, Sabnis (1944) in his Presidential address to the same congress made similar observations. He stated that "the accounts are merely descriptive. Plant ecology aims at not only describing the finer details of plant distribution, but also elucidating the origin, development and structure of vegetation. It is not merely descriptive (although much of its work is still in the descriptive stage), it is an experimental science, a 'higher physiology' in which the systematist, the physiologist and the agronomist have a common meeting ground". With the advances in ecology in other countries we may add Soil Scientist, Geologist, Meteorologist and even Human Sociologist, Historian and Geographer to the ecological team proposed by Sabnis.

Ecology is the synthesis of all the diverse sciences that are concerned in the study of plant's environment and new ecologist has been or is emerging from the ecologist of old in India, although in other countries great advances have already been made especially in Sweden and Danmark. This present phase in the ecological research is, therefore, of synthesis and application of ecological knowledge to problems of regeneration, growth, development and management of forests and other forms of vegetation. As early as 1918, Hole in his Presidential address to the Boatany Section of the Indian Science Congress has already drawn attention to the necessity of this work, and recently Champion (1939) has again stressed in his address to this Congress.

The ecological knowledge will also be applied to problems of erosion, proper land utilization, *Vana Mahotsava,* nature conservation, and other human affairs. In his address to the Botany Section of the Indian Science Congress in 1942, Bor discussed the role of ecology with special reference to Indian conditions and problems. He concluded his address with the following words :—

> "Take the following fields of human activity and endeavour : forestry, agriculture, grazing, land classification and planning, management of wild life, anthropology, social science, medicine and epidemiology and many others of like nature, in which the reactions and co-actions of living things upon one another lead to certain states and raise certain problems – I submit to you that the only logical approach to these problems is the dynamic one of modern ecology".

Any further stress on the aims and scope of ecology in India will be superfluous.

As much work on the first two stages in the ecological research has yet to be done in this country, the most pressing need that this review brings to light is of carrying out in all States intensive and extensive floristic and ecological studies, so that ecological knowledge could be applied to urgent problems of reconstruction of this ancient land.

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CULLENIA EXCELSA, WIGHT. (*C. ZEYLANICA*, GARDNER, *DURIO ZEYLANICUS*, GARDNER)

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Trade name—Wild Durian (Gamble).

Local names—Tamil : *Malai-kongi, Aini-pillao, Vedupla ;* Cinghalese : *Katu-boda, Kabodda, Karani ;* Travancore hills : *Kar-ayani ;* Malayalam : *Mullen-chakka, Mullanchakka, Vediplavu, Karayani.*

General—A medium sized to very large evergreen tree of pyramidal shape, with a straight bole often 60 feet high up to the first main branch and having a girth of 10 feet at breast height. In old trees the bole is frequently fluted. The tree is easily distinguished in the field by the oil glands found on the underside of the leaf which give it a golden colour (*Emp. For. Rev.*, Vol. 32, 2, 1953, 138). The bark is smooth, grey and its dehiscence is scroll-like, i.e., in sheets rolled up at the ends. The blaze, i.e., the colour of the inner bark is pink.

Botanical description—Leaves simple, elliptic, accuminate, bright shining green above, silvery and densely scaly beneath. *Flowers*—densely packed on contracted branches, short peduncled, pointed at the base. *Fruit*—size of an orange or often 4–6 inches in diameter, spherical and densely covered with prickles. *Seeds*—few.

Distribution and habitat—The tree is a native of the evergreen forests of the Western Ghats of Deccan, from Coorg southwards, through Wynaad, Palghat, Nilgiris, Anamalais, Iyamalais, Palni hills, and hills of Travancore-Cochin up to 5,000 feet elevation. It is also a native of the central districts of Ceylon in moist regions between the elevations 2,000–5,000 feet (Brandis).

In India the tree inhabits localities lying between about 8° 5′ and 12° 30′ North latitudes and 75° 20′ and 77° 40′ East longitudes. In the natural habitat of the tree the climate is humid. The absolute maximum shade temperature varies usually from 95° to 100° F., the absolute minimum from 55° to 65°F., and the rainfall from about 80 to 200 inches or more.

Forest types and associate trees—The tree is a native of the Tropical Wet Evergreen forests of the Deccan Peninsula and is found in the Western Tropical Evergreen type (H. G. Champion, p. 18). The following are a few typical localities where the tree occurs with its associates.

Wynaad ghats, Madras—Higher elevation sholas, with *shola* type of forest. *Floristics* : *Cullenia excelsa* (abundant), *Palaquium ellipticum* (abundant), *Mesua ferrea*, and many other evergreen trees among which *Calophyllum* 2 species, *Artocarpus* 2 species, *Dipterocarpus indicus* and others are present (A. N. Sarma's Working Plan, 6).

Coimbatore (South) division, Madras—Wet sholas of Kallar valley. *Floristics* : *Poeciloneuron-Cullenia* association with an almost pure crop of *Poeciloneuron indicum* and a small admixture of *Cullenia excelsa*. This association, which appears to be due entirely to edaphic factors, is found in places where the soil has a high moisture content for the greater part of the year (T. V. V. Ayyar's Working Plan, 7).

Palghat ghats, Madras—The tropical rain forest, with the following associations : (1) *Cullenia-Palaquium* association, the dominant trees of which are *Cullenia excelsa* and *Palaquium-ellipticum ;* this is found between elevations 2,500 and 3,500 feet on aspects with

comparatively heavy rainfall and deep, well-drained soil. (2) *Vateria-Cullenia* association, in Attapadi block VI, with *Vateria macrocarpa* (preponderating) and *Cullenia excelsa*, *Palaquium ellipticum*, *Mesua ferrea* and others. (3) *Mesua-Cullenia* association with *Mesua ferrea* and *Cullenia excelsa*, in Anangurthodu block of Attapadi blocks I to VI, where aspect or elevation prevents the development of association No. (1) above (T. V. V. Ayyar's Palghat Working Plan, 12–15).

Nilambur hills, Madras—Evergreen forest between 1,500 and 4,000 feet elevation. *Floristics : Palaquium ellipticum* (commonest tree), followed by *Cullenia excelsa* and *Calophyllum elatum* in order of abundance. Above 5,000 feet elevation, *Calophyllum elatum* is replaced by *Mesua ferrea* and *Elaeocarpus* spp. (R. S. Browne's Working Plan, 4).

Shencotta division, Travancore-Cochin—Dense evergreen forest with the trees *Hopea parviflora*, *Cullenia excelsa*, *Dipterocarpus indicus*, *Dichopsis elliptica* and others (M. N. Menon's Working Plan, 11).

Ambasamudram range, Tirunelveli cum Ramnad division, Madras—Shola type with the trees *Mesua ferrea*, *Cullenia excelsa*, *Gluta travancorica*, *Palaquium ellipticum*, *Hopea parviflora* and others in the top storey (Lasrado's Working Plan, 14).

Leaf shedding, flowering and fruiting—Though the tree is evergreen, there is a perceptible fall of old leaves during the dry, hot season of March, which is accompanied almost at the same time by a new flush of leaves. Another, though less perceptible flush of new leaves appears after the cessation of the summer monsoon in October–November, especially in localities where the S.W. monsoon brings the bulk of the annual rainfall. The flowers appear during the hot season about February–March and the fruits ripen during the rainy season.

The tree seeds profusely almost every year. The few seeds fround in each fruit are each 1·3 inches long, brown, shining, with a hard testa surrounded by a large fleshy white arillus (Troup).

Silvicultural characters—The tree is a strong shade bearer, more so than *Mesua ferrea* with which it is frequently associated. Established seedlings and saplings, however, benefit by overhead light and free crown space. It often tends to form nearly pure patches where conditions are favourable for its growth and in the Palghat ghat forests this tendency is stronger in *Cullenia* than in *Mesua ferrea* which is one of its chief associates. *Cullenia* likes a deep, moist soil where drainage is free, and it does not tolerate swampy conditions. It coppices fairly well; seedlings 2–5 years old when cut back after injury sustained during forest exploitation are known to have coppiced quite satisfactorily. The tree is sensitive to fire.

Natural regeneration—This is generally adequate, if not prolific, in shady situations in evergreen forests where deep, moist, well-drained fertile soil exists. Its abundant seeding and the fact that the seeds are not easily damaged by insects as in the case of *Mesua ferrea* makes *Cullenia* come up gregariously in favourable situations. Generally speaking, conditions favourable for the recruitment and establishment of the seedlings of *Cullenia* appear to be : (1) adequate shade, (2) freedom from the congestion of forest undergrowth. A couple of experiments done in the Chenat Nair reserve of Palghat, Madras (elevation 2,500 feet) have indicated in a broad and general way that seedlings of *Cullenia excelsa* can survive best under the shade of natural evergreen forest and that heavy weeding is definitely harmful to its survival at this stage (E.P. No. 34, Palghat Division, Madras). Other experiments (E.P. No. 26, Palghat) in a clearfelled evergreen forest showed that the clearing had favoured the growth of *Cullenia* saplings. The general indications, therefore, are that recruitment and establishment of the species can be secured even under heavy shade ; and letting in of light is definitely beneficial at a later stage when adequately well established regeneration is present on the soil.

Artificial regeneration—The tree can probably be raised by both sowing its seed directly and planting nursery raised seedlings.

About 76 seeds of *Cullenia* weigh one pound. The seeds do not store well. Their viability is believed to be high. An attempt made to raise seedlings of *Cullenia* at Dehra Dun in unshaded nursery beds proved a failure.

Rate of growth—The rate of growth of seedlings and saplings is slow. The average height of seedlings, coppiced and uncoppiced, recorded between 1921 and 1931 is given below :—

Cullenia excelsa—Rate of growth of seedlings and saplings.

	Average height on						Mean annual height increment between 1924 and 1931 feet
	December 1921 ft.	in.	February 1924 ft.	in.	March 1931 ft.	in.	
Coppiced ..	0	8	1	6	13	0	1·64
Uncoppiced	..		5	6	16	0	1·50
	13–9–25		18–10–27				
Coppiced ..	2	10	6	6			
Uncoppiced	6	7	9	0			

Utilization—*Cullenia excelsa* is a straight grained, pale pinkish or reddish-brown, light (39 lbs./c.ft. Limaye ; 32 to 39 lbs. at 12 per cent moisture, Pearson and Brown) wood resembling in some respects the wood of *Calophyllum* but lacking its lustre. Some of the distinguishing features of the wood are its obscure or ill-defined growth rings and pores of medium size which are visible without a lens on clean-cut cross sections. The wood works easily and well and responds excellently to polishing treatments.

The timber is not strong and is of the packing-case and match-board class. It makes plywood of the second class. Limaye, has given the strength properties of the wood from Malabar expressed in percentages of teak as follows :—Weight : 90 ; strength as a beam : 95 ; stiffness as a beam : 105 ; suitability as a post : 100 ; shock-resisting ability : 105 ; retention of shape : 70 ; shear : 70 ; hardness : 85 (*Indian For. Rec.*, Ut. *n.s.* Vol. 3, 5, 14–15).

The wood is easily attacked by fungus which rapidly destroys it ; it is also rapidly discoloured. It is said that if the logs are converted when fresh and kiln-seasoned the fungus is eliminated. In Dehra Dun the logs were attacked by discolouring fungi within 5 days of their receipt. In the forest, conversion when the logs are absolutely green and open-stacking to expose the pile to maximum ventilation is the best. If quickly seasoned, excellent boards can be obtained (Pearson and Brown). If handled with care it seasons without trouble.

The wood is not durable in the open but is fairly so under cover. It absorbs preservatives satisfactorily. Seasoned railway sleepers absorbed 15 to 20 lbs. of the preservative within a short time and under relatively low pressure.

Uses—The timber is usually employed for boards, lining and backing furniture, wooden partition in buildings, poles and general carpentry. It converts well into plywood, but its stems are generally fluted and buttressed and are, therefore, not very suitable for peeling except logs under 5 feet in girth (Note by the Utilization Branch, F.R.I., 1940). It makes plywood of the second class (*Indian For. Bull.* No. 162 n.s. Silviculture, 3). The annual supplies of the timber from the Western Ghat forests have been estimated to be 3,000 tons.

Cullenia excelsa, lower portion of bole showing buttresses.

DISTRIBUTION OF CULLENIA EXCELSA, Wight.

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THE INFLUENCE OF INITIAL SPACING ON EARLY MORTALITY AND GROWTH IN THE *CASUARINA* PLANTATIONS AT BALUKHAND, PURI DIVISION, ORISSA

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SUMMARY

An investigation, comprising 54 sample plots, was started at Balukhand in 1941, with a view to determining the influence of initial spacing, subsequent thinning treatment and rotation age on volume production and financial returns from plantation *Casuarina* in the locality. Examination of the data collected till the age of 7 years, by which time no thinning treatment had been given to any of the plots, reveals that initial espacement has a clear effect on mortality rate, diameter development and production of Basal area during this phase of the crops' life.

Three initial spacings, viz., 6, 9 and 12 feet square have been under trial. Increase in planting espacement cuts down mortality rate and accelerates diameter growth. But while the difference between 6 feet spacing on the one hand, and 9 and 12 feet spacings on the other, is highly significant, that between the latter two alone is not significant at the 5% probability level. Basal area production shows an exactly opposite trend. The drop in this parameter from 6 feet to 9 feet spacing is not significant. while that from either of these two to the 12 feet spacing has turned out to be highly significant.

Statistical and graphical analyses of the data indicate that the 9 feet square espacement probably provides the crop optimum conditions of growth till the age of 7 years.

INTRODUCTION

Casuarina equisetifolia Forst. is one of the top quality fuelwoods. What is perhaps even more important, it is eminently suited for afforesting the sterile sandy beaches and shifting coastal sand dunes and gives remarkably high yields even on these infertile soils. It is, therefore, only natural that the species has been raised on increasingly large areas, particularly along the sea board, to meet the fuel scarcity in the thickly populated coastal districts and for fixing the inblowing sands.

As *Casuarina* has been raised under a variety of conditions the plantation techniques vary considerably. The initial spacing, for example, has varied from 3 × 3 feet to 10 × 10 feet, while the rotation age may fluctuate from 7 to 30 years. The tending and thinning practices, similarly, have been widely different. The practice adopted in a particular locality is, in most cases, based on the general local experience and personal views of the foresters concerned rather than on unimpeachable experimental evidence. An elaborate investigation was started by the Orissa authorities, in consultation with the Central Silviculturist, Forest Research Institute in 1941 with a view to determining the influence of initial sapcing, subsequent thinning treatment and rotation age on volume production and financial returns from plantation *Casuarina* at Balukhand. This experiment will have to run its full anticipated course of 20 years before a verdict on the original objects could be given. Examination of the records during the course of routine computations indicated that initial spacing exercises a strong influence on mortality and development of the species during the early period of the crop's life. The object of the present note is to record some observations based on this interesting investigation.

SITUATION, SOIL AND CLIMATE

The Balukhand plantation lies along the sea coast at a distance of 3 to 7 miles to the east of Puri town in 85° 50′ E., longitude and 19° 48′ N., latitude. The soil is almost pure sand of considerable depth, varying in texture from very coarse to fine grained. Occasionally yellow shale and ferrugineous matter are found mixed with sand over small patches.

Being near the sea the climate is equable, hot and humid. The mean annual temperature is 81°F. and exhibits very little variation from year to year. The mean temperatures for January and May–June, which are the coolest and hottest periods of the year, fluctuate between 70°F. to 74°F. and 84°F. to 87°F. respectively. The normal rainfall for Puri is 54 inches, over 60% of which is received during the period mid-June to mid-October.

DESIGN AND LAY-OUT OF THE INVESTIGATION

It was decided to restrict the treatments to the 9 different combinations of 3 planting espacements (6, 9 and 12 feet square) and 3 thinning patterns (no thinning, one semi-mechanical thinning at the age of 10 years and two semi-mechanical thinnings at the age of 7 and 15 years, each time reducing the number of stems by 50%). For collecting information regarding the influence of rotation age on yields total crop was to be measured at the ages of 7, 10, 15 and 20 years. Sets of 18 plots, each one-tenth acre in size, were laid out in the annual coupe in 3 successive years, starting from 1941. Each set was divided into two blocks of 9 plots by arranging the plots in descending order on the basis of the average dominant height of the previous rotation crop and placing the first 9 plots in one set and the remaining 9 in the other. The nine treatments were allotted in a purely random fashion within each block. Thus a total of fifty-four plotsw as laid out in the years 1941 to 1943, giving six replications of the 9 initial spacing-cum-thinning treatments. Ignoring the three thinning treatments, which did not come into the picture till the age of 7 years, the design is reduced to the trial of 3 espacements allotted at random in two stratified blocks of 9 plots each in a year, the experiment being repeated over 3 years. There are thus six plots for each espacement in a particular year and 18 plots in all the 3 years taken together.

PLANTING AND WATERING TECHNIQUES

Unfortunately the experimental records do not give full details about the planting operations, particularly the seed origin and comparability of the nursery stock. The new crops in the sample plots were raised according to the standard territorial practice described by Sharma (15). In brief, 5 to 6 months old potted nursery plants are planted in previously prepared pits during July–August after the summer monsoons have properly set in and the whole plantation is watered on uniform lines for the first two dry periods of December to June in normal years and for an extra drought season in case of specially dry weather. The 1941 plots, for example, would have normally been watered during the periods December 1941 to June 1942 and December 1942 to June 1943. Casual failures of seedlings are replaced during August–September of the same and the succeeding years with transplants taken from the original nursery beds. Thus the plots may be taken to be fully stocked initially. The planting stock for the experiment was not raised specially for the purpose but was taken from the mass scale nursery stock raised for the normal planting operations in the locality. Although no special mention of the fact is made, it would be fairly safe to assume that the stock used in all the plots of the same year was comparable from the point of view of seed origin and vigour of plants.

MORTALITY UNDER DIFFERENT SPACINGS

As already mentioned the investigation is not yet fully ripe for determining the comparative development of *Casuarina* crops under the different treatments tried. Meanwhile the unforeseen factor of early mortality has stepped in. This was exceptionally high in 1943

plots, wiping out more than 50% of the stems in some cases, with the result that it was decided to abondon this set. The mortality till the age of 7 years, under different spacements, has been as under :—

TABLE 1.—*Mortality per cent resulting under different planting spacements up to the age of 7 years*

Spacement	6×6 feet	9×9 feet	12×12 feet
Number of transplants per plot ..	297	133	65
Casualty % in 1941 plots	22	9	3
Casualty % in 1942 plots	40	30	24
Casualty % in 1943 plots	51	30	28
Average casualty % for the treatment ..	37	23	18
Number of plots planted	6+6+6	6+6+6	6+6+6

Statistical analysis of the entire data has disclosed that the difference between the casualties under the 6 feet espacement on the one hand and 9 or 12 feet espacements on the other is significant at 1 per cent probability level while that between the two wider espacements falls below the five per cent significance level. A close examination of the mortality data for the three sets individually and for the entire investigation collectively with the help of Graph 1 shows the trend in mortality % to be consistent in all cases in that it rises with a fall in planting espacement. This rise is, however, not so pronounced from the 12 feet to the 9 feet espacement but becomes steep with further reduction in the growing space.

Unfortunately no observations regarding condition of individual plants were recorded before the age of 7 years when some of the plots became due for first thinning. At this stage the serial numbers were painted on individual stems and their diameters were recorded, those found dead being omitted. Considering that routine casualties were replaced during the first two growing seasons and the plants were systematically watered till they were 3 years old, the above casualties can be safely assumed to have taken place between the ages of 4 and 7 years.

DIAMETER AND BASAL AREA GROWTH

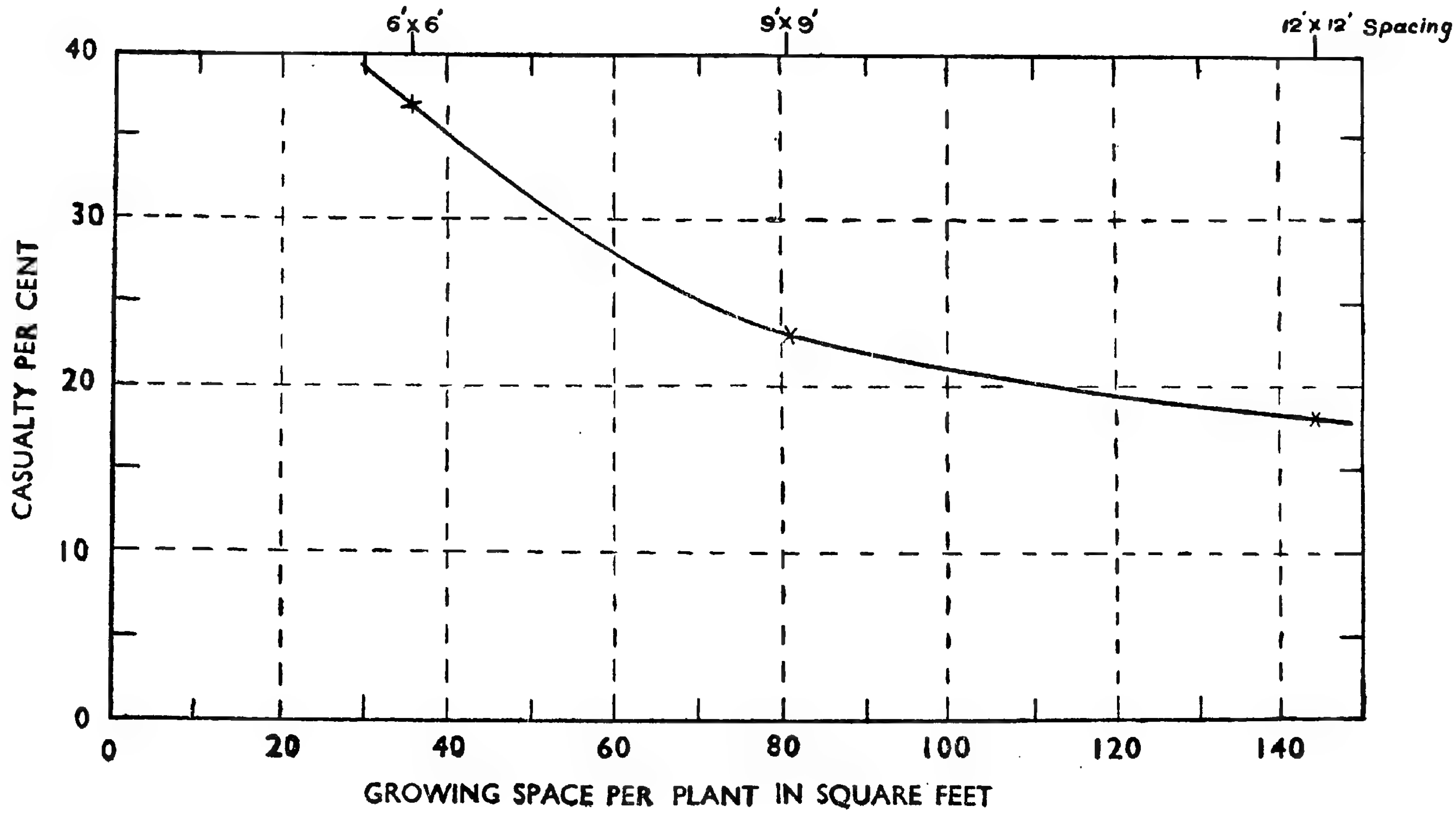
The position regarding crop diameter and total basal area production under different spacements at the end of seven years is given in Table 2.

TABLE 2.—*Crop diameter and basal area per acre resulting under different planting spacements at the age of 7 years*

Spacement	6×6 feet		9×9 feet		12×12 feet	
Character	Crop diameter in inches	Basal area per acre sq. ft.	Crop diameter in inches	Basal area per acre sq. ft.	Crop diameter in inches	Basal area per acre sq. ft.
1941 plots ..	2·6	33·3	3·4	29·7	3·9	25·4
1942 plots ..	2·8	32·5	3·2	22·3	3·5	17·5
1943 plots ..	2·8	30·1	3·9	31·3	3·8	19·1
Average for 3 years..	2·7	32·0	3·5	28·0	3·7	20·7

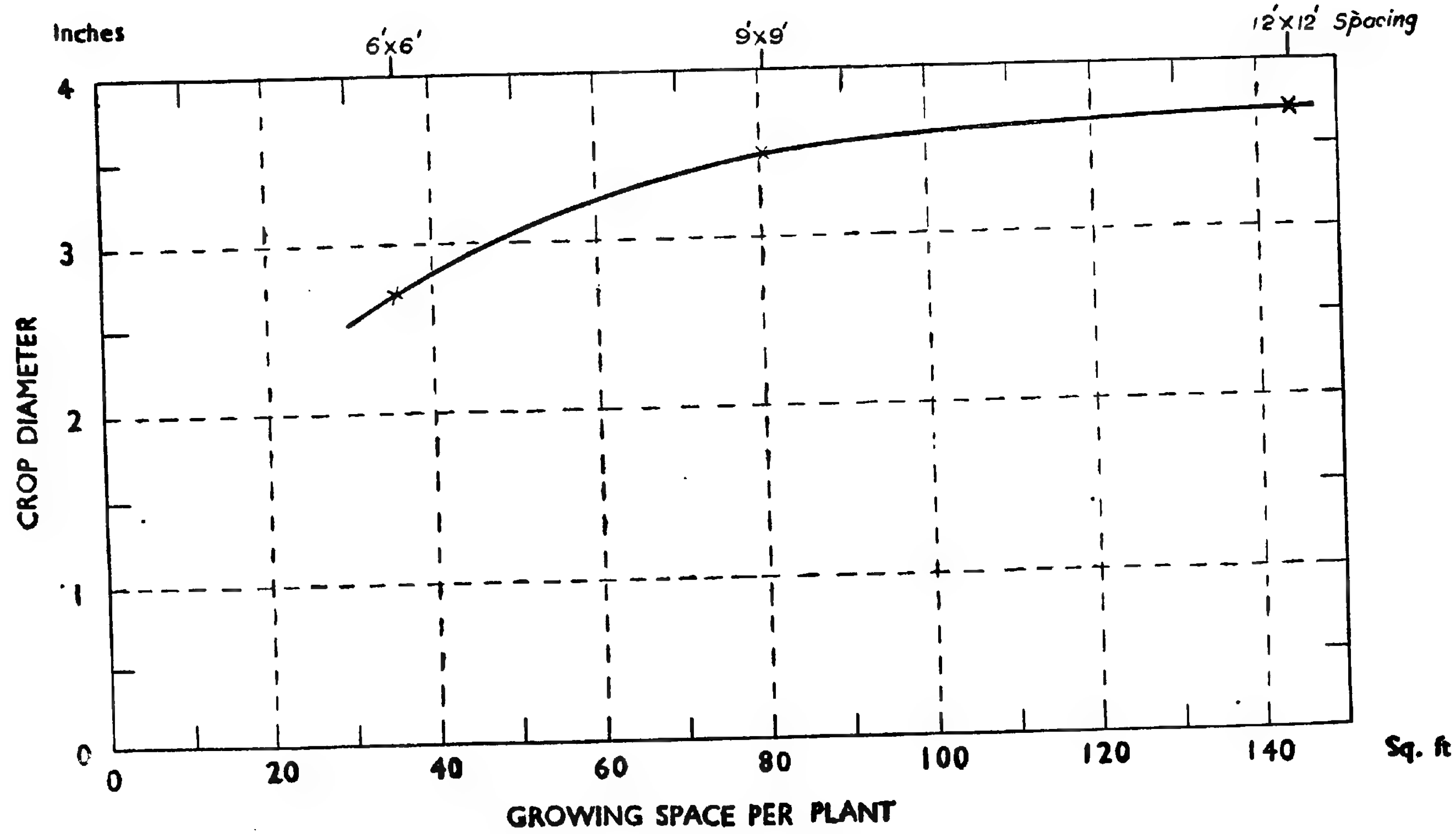
GRAPH 1.

RELATION BETWEEN CASUALTY % TILL 7 YEARS AGE AND GROWING SPACE ALLOWED PER PLANT



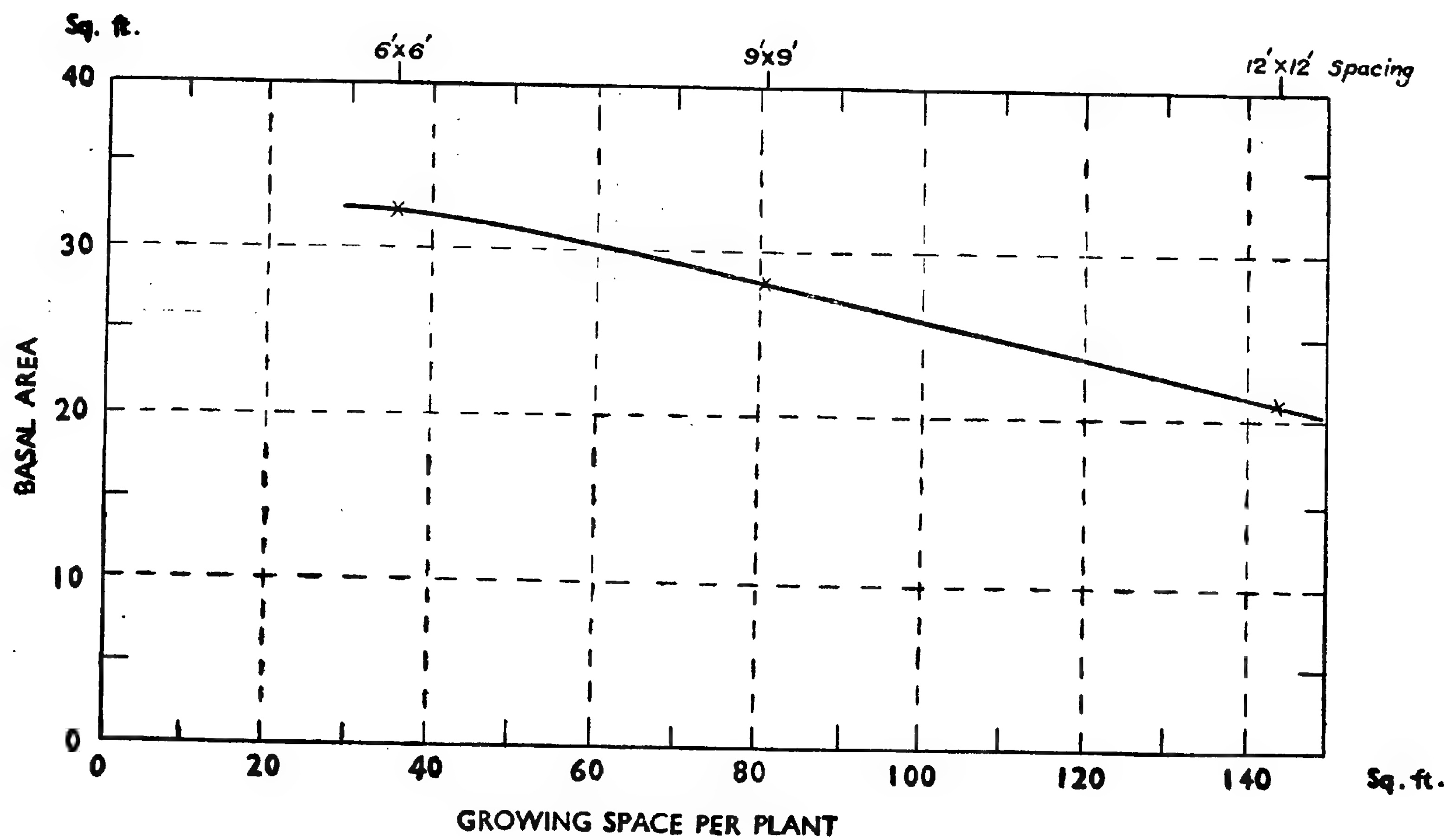
GRAPH 2.

RELATION BETWEEN CROP DIAMETER TILL 7 YEARS AGE AND GROWING SPACE ALLOWED PER PLANT



GRAPH 3.

RELATION BETWEEN BASAL AREA TILL 7 YEARS AGE AND GROWING SPACE ALLOWED PER PLANT



It is apparent that crop diameter rises and basal area falls with an increase in initial spacing. On analysis the crop diameters resulting from the 9 feet or 12 feet spacements have turned out to be significantly superior at 1% level to those obtained under the 6 feet espacement while difference between the first two themselves is not significant at 5% level. As opposed to this the basal area production falls with a rise in spacement. The difference between the 6 feet and 9 feet spacements on the one hand and 12 feet spacement on the other is significant at 1% level while that between the first two is not significant at 5% level.

VISUAL IMPRESSIONS

The author got an opportunity of seeing these plots in December 1953 by which time one-third of the plots had been thinned at the age of seven years, another third at the age of ten years, while the remaining plots had not been thinned at all. The following observations are based on the visual impressions gained during the course of inspection of the plots in the field :

1. The three sets are situated on flat ground at practically the same distance from the sea. The edaphic and environmental factors, to all outward appearance, are identical.

2. Though the failures in a few cases have been in small patches, the general pattern has been for odd trees to die all over the area.

3. (i) The 12 feet espacement with 50% mechanical thinning at 7 or 10 years age results in too open a crop which, probably, cannot result in maximum volume production. The unthinned crops have closed up though no suppression has so far taken place. This spacing, on the whole, appears to be too wide.

   (ii) Unthinned crops in the 9 feet espacement plots have closed up and are generally fully stocked. Crown differentiation has set in, though competition does not appear to be intense. The plots thinned in the 7th and 10th years look too open. Removal of 50% growing stock results in drastic opening of the canopy which seems hardly justifiable in crops aiming at maximum fuel production. With this treatment a lighter thinning (say 'C' grade, ordinary) at the age of 9 to 11 years appears to be the best.

   (iii) The crops initially planted at 6 feet spacement do not present the same robust appearance even where they have received a thinning in the 7th year. This indicates that the competition between the adjoining plants is so intense in the younger stages that even the removal of 50% stems in the 7th year could not completely remove its ill affects.

DISCUSSION

(*a*) *Mortality*—The problem of mortality in *Casuarina equisetifolia* plantations has baffled Indian foresters for over half a century. In spite of all normal precautions, plantations of the species have continued to suffer from sudden large scale deaths. Various workers have tried to explain the phenomenon from different angles. Moisture and nutrient deficiency, water logging, excessive alkalinity or acidity of the soil and fungal diseases have been held responsible for heavy casualties in individual instances. No single explanation, however, holds good for all the known cases. So far as early mortality is concerned, drought, caused

either by failure of rain, or unfavourable soil morphology, or sudden lowering of the water-table, has generally been suspected to be the chief factor, killing the plant outright for lack of moisture or predisposing it to fungal attack. Cases have, however, been recorded in which drought apparently did not have much to do with the mortality and the large scale deaths were caused by some unknown pathogen which, at least in one case, was controlled by sterilizing the soil.

Trichosporium vesiculosum or any other serious fungal disease has not so far been noticed at Balukhand. Drought has usually been suspected to be the chief cause of mortality in the locality. Casualty % in the case of the present investigation shows a strong correlation with the growing space available to individual plants. The pattern of failures, as already observed, has been by single plants or small groups rather than in large patches, and the survivals, particularly in the case of wider spacings, are growing vigorously. These facts indicate that root competition in this locality sets in at a very early age and that the most likely primary cause of death at this stage, most probably, is moisture deficiency. This might be killing out the plants by sheer drought or might first be reducing their vitality through excessive dehydration of the bacterial nodules on the side roots, thereby, cutting off their major source of nitrogen supply. An increase in planting spacement cuts down mortality rate. As illustrated, vide Graph I, this relationship becomes less pronounced with an increase in the growing space allowed per plant. Thus, while the change from 6×6 feet to 9×9 feet spacing involving an increase of 45 sq. feet growing space per plant, results in 15% drop in casualties which is highly significant in the statistical sense, the change from 9×9 feet to 12×12 feet spacing, involving a difference of 63 sq. feet growing space per plant results in only 5% reduction in casualties which is not significant at the 5% probability level. Graph I also indicates that reduction of planting spacement from 9×9 feet to 8×8 feet is likely to increase the mortality rate by 4% and is thus not advisable. The 9×9 feet spacing is the lowest which provides full growing space for the healthy existence of the young plants. With closer spacing growth conditions become unfavourable rapidly, while increase in the planting distance does not improve matters to any appreciable extent.

(*b*) *Diameters*—This investigation clearly proves that upto the age of 7 years crop diameter increases with a rise in initial espacement. As in the case mortality %, the relationship between crop diameter and growing space per plant is not linear (vide Graph 2). Beyond the 9×9 feet spacing the increase in size of individual plants tapers off rapidly, so that the difference between the crop diameters resulting under this and the 12×12 feet spacings is not significant. It could, therefore, be safely concluded that at the time of formation the plants need not be spaced wider than 9 feet from the point of view of thickness of individual plants.

(*c*) *Basal area*—As opposed to crop diameter, maximum basal area production is obtained under 6×6 feet spacing. Increase in espacement is accompanied by reduction in basal area production up to the 7 years' age. As illustrated in Graph 3 the relationship here, too, is non-linear.

The 9 feet spacing appears to be the critical point in this case also. As already stated the difference between 6 feet and 9 feet spacements is not significant at 5% probability level while that between either of these and the 12 feet spacing is highly significant. Thus from the view-point of basal area production the planting distance should not be wider than 9 feet square. The 6×6 feet spacing will also give equally good (or perhaps slightly better) basal area production up to the age of 7 years. But since crops resulting from the closer spacing are not healthy and vigorous in appearance, it would not be surprising if they lagged behind the wider spacings during the later part of their lives.

(*d*) *Optimum initial spacing for the locality*—The results of mortality and crop diameter data analysis show that 9 feet square spacing, most probably, provides the individual plants the full growing space required for their healthy existence and good growth. This spacing also provides satisfactory conditions from the view-point of basal area increment. An increase in initial spacing to 12 × 12 feet does not produce any significant difference from the point of view of mortality and diameter increment though it drastically reduces the basal area production and hence the total yield. As opposed to this reduction of initial spacing to the 6 × 6 feet limit produces sharp adverse effect on mortality rate and diameter increment though it leaves the basal area increment practically unaffected. Under the Balukhand conditions the 9 × 9 feet spacing, therefore, appears to be the best.

Sharma while writing about this plantation, states that "Planting distances have varied in the past from 10 × 10 feet, 10 × 8 feet to 9 × 9 feet but the one largely adopted was 10 × 10 feet. Since 1942, however, planting is being done at a spacing of 8 × 8 feet on the advice of the Central Silviculturist and the idea is to continue with this espacement untill the experiments laid out to test optimum planting distances and thinning technique have produced conclusive results and shown some other more suitable spacing". The above advice was primarily based on field observations. The results of this investigation prove that 8 × 8 feet spacing was quite a close guess. The initial espacement can be increased to 9 × 9 feet without adversely affecting the basal area increment and consequently the total volume production. This will cut down the requirements of nursery stock by about 27% and will also result in a proportionate saving on cost of planting and watering during the first two dry seasons. As the size of the individual trees composing the final crop is an important consideration in fixing the rotation for this plantation, the wider spacing, by inducing faster diameter growth in the early part of the crops life, may also help in reducing the rotation age.

CONCLUSIONS

The present investigation strongly indicates that :

(i) Early mortality in *Casuarina* plantations at Balukhand is closely linked up with the growing space provided to individual plants. This suggests that root competition in the locality sets in at an early stage and moisture deficiency is the most likely cause of casualties till the 7 years' age.

(ii) As would be expected, diameter development varies with spacing. Increase in spacing accelerates diameter growth. The gain in this respect, however, is not significant after the 9 feet spacing limit is passed.

(iii) Basal area production, generally speaking, falls with wider spacings. This reduction is not significant till the 9 feet spacing, after which stage the fall becomes very rapid.

(iv) The 9 feet square spacing provides the most suitable conditions for the development of *Casuarina* at Balukhand from the point of view of survivals, diameter development and basal area increment.

(v) As compared with the 8 feet spacing now practised at Balukhand, the 9 feet spacing will result in about 27% saving in the plantation costs without adversely effecting volume increment.

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INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART XXII.—WRAPPING PAPERS FROM *TREMA ORIENTALIS* BLUME

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SUMMARY

Laboratory experiments on the production of sulphate and soda pulps for wrapping papers from *Trema orientalis* Blume (*kargol*) are described. Results of pilot plant experiments are also included. These experiments have shown that *Trema orientalis* is a promising raw material for the production of wrapping papers in high yields and of satisfactory strength properties. Since this wood is short-fibred, it will be necessary to mix a suitable quantity of bamboo sulphate pulp with *kargol* pulp for manufacturing wrapping papers on commercial paper machines. Six samples of wrapping papers from *Trema orientalis* are appended in this bulletin together with two samples of wrapping papers from bamboo.

INTRODUCTION

Trema orientalis Blume (*kargol*) is an exceedingly fast growing tree[1]. The distribution of this species in India and adjoining countries has been given in an earlier publication[2]. This species is found on a large scale in Bombay State. Hence, the Conservator of Forests, Utilization and Engineering Circle, Bombay State, requested this Institute to carry out an investigation on the utilization of this species for paper manufacture. The results of the experiments on the production of writing and printing papers from *kargol* have already been published[2]. The present bulletin records the results of the experiments on the production of wrapping papers from this timber.

THE RAW MATERIAL

The Divisional Forest Officer, North Thana, Bombay State, arranged the supply of the wood (4 tons) for these experiments from Palghar and Sanjan Ranges. The supply consisted of stem wood and branch wood. The logs from the stem wood were $9\frac{1}{2}$–$11\frac{1}{2}$ feet in length and 4–9 inches in diameter and those from the branch wood $13\frac{1}{2}$–15 feet in length and $1\frac{1}{2}$–4 inches in diameter. The logs were received without bark. The colour of the wood was light reddish-brown. The logs were chipped in the factory chipper of this Institute and screened on the factory screen. The screened chips were used for the laboratory as well as the pilot plant experiments. The proximate chemical analysis of this wood is given in an earlier publication[2].

FIBRE DIMENSIONS

The fibre dimensions of the bleached sulphate pulp from *Trema orientalis* have been reported in the earlier publication[2]. The pulp was prepared by cooking the chips with 22% total chemicals (on the basis of the oven-dry material) at 162°C. for 4 hours. The pulp was bleached with bleaching powder and used for the determination of fibre length and diameter. The average fibre length was 1·05 mm. and the average fibre diameter 0·0286 mm. The fibre length distribution is given in Table I and fibre diameter distribution in Table II.

TABLE I

Fibre length distribution

Fibre length mm.	Number of fibres	% of fibres
0·66 to 0·75	5	2·5
0·76 to 1·00	91	45·5
1·01 to 1·25	93	46·5
1·26 to 1·44	11	5·5
TOTAL	200	100·0

TABLE II

Fibre diameter distribution

Fibre diameter mm.	Number of fibres	% of fibres
0·0132 to 0·0175	5	2·5
0·0176 to 0·0225	33	16·5
0·0226 to 0·0275	61	30·5
0·0276 to 0·0325	59	29·5
0·0326 to 0·0352	42	21·0
TOTAL	200	100·0

PRODUCTION OF PULP

The digestions were carried out by the sulphate and soda processes in a vertical stationary mild steel autoclave of 3-litre capacity. For each digestion 200 g. of chips were used. For the sulphate digestions, 8–12% total chemicals (on the basis of oven-dry raw material) were used. The digestions were carried out at 142°, 153° and 162°C. for a period 4½ hours – 1½ hours for raising the temperature from the room temperature to the maximum cooking temperature and 3 hours at the maximum cooking temperature. The cooking liquor contained sodium hydroxide and sodium sulphide in the ratio of 2 : 1.

After the digestion, the chips were found softened. These chips were kollerganged in the factory kollergang for 5 minutes and then washed on a 66-mesh sieve with water. The yield of the pulp was then determined. The pulp was beaten in the Lampen Mill to a freeness of about 300 c.c. (C.S.F.). Standard sheets were made on the sheet making machine. These pulp sheets were conditioned at 65% R.H. and 58°F. and tested for strength properties.

The digestion conditions, pulp yields, colour of the pulps, and strength properties are recorded in Table III.

Digestions were also carried out by the soda process in order to compare the colour and strength properties of the pulps. Digestions were carried out under conditions used for sulphate cooks. The soda pulps were also processed as in the case of sulphate pulps excepting that the kollerganging in the factory kollergang was carried out for 15 minutes. The soda pulps before kollerganging were found less soft than the corresponding sulphate pulps.

Data of the laboratory experiments on the production of soda pulps are given in Table IV.

PILOT PLANT TRIALS

In order to confirm the results obtained in the laboratory experiments, three pilot plant trials were carried out. About 550 lb. chips (on the oven-dry basis) were used for each digestion. The digestions were carried out in a vertical stationary mild steel digester (100 cubic feet capacity) of the indirect heating-forced circulation type. The sulphate process was used in one case and the soda process in the other two cases. In the case of the soda process, both the digestions were carried out under similar conditions and, therefore, the results of only one trial by this process are recorded here.

After cooking, the softened chips were treated in the rod (roller) mill. Thirty-two rods of different diameters weighing 1,100 lb. were used in the rod mill. The pulp was then washed in the potcher, transferred to the machine chest and taken out at the first press of the Fourdrinier machine. The yield of the pulp was then determined. The weight of the screenings left on the flat screen of the Fourdrinier machine was also determined.

The screened pulp was beaten in the factory beater at 5% consistency and rosin size and alum were added. Wrapping paper was made from this stock on the Fourdrinier machine. As there were several breakages during the run, a portion of this pulp was mixed with beaten bamboo kraft pulp and wrapping papers were again made. Papers were made in two different substances. The run of the papers was smooth. The papers were conditioned at 65% R.H. and 68°F. and tested for their strength properties. Samples of six different varieties of wrapping papers are appended in this bulletin.

In order to compare the strength properties of wrapping papers from *Trema orientalis* with those of wrapping paper from 100% bamboo pulp, crushed, cut and screened bamboo was digested by the sulphate process and the pulp was prepared using the rod mill. Screenings were negligible in the case of bamboo sulphate pulp. Wrapping papers in two different substances were made and tested for strength properties after conditioning at 65% R.H. and 68°F. A sample each of these two wrapping papers is appended. This bamboo sulphate pulp was used for blending with the soda pulp from *Trema orientalis* in the preparation of wrapping papers (vide Serial Nos. 2*b* and 2*c*, Table VI).

The digestion conditions and pulp yields are recorded in Table V and the strength properties of papers in Table VI.

For admixing with the sulphate pulp from *Trema orientalis*, bamboo kraft pulp was prepared by digesting crushed, cut and screened bamboo with 14% total chemicals (NaOH : Na_2S = 2 : 1) at 153°C. for $4\frac{3}{4}$ hours. The percentage of the chemicals in this case is expressed on air-dry basis of the raw material. The pulp was not treated in the rod mill. This was washed in the potcher and beaten in the beater. The strength properties of standard sheets made from this beaten pulp are given in Table VII. For comparison, standard pulp sheets were also made from the following pulps beaten in the factory beater (before the addition of the sizing materials): *kargol* sulphate and soda pulps (vide Serial Nos. 1 and 2, Table V) and bamboo sulphate pulp (vide Serial No. 3, Table V). The strength properties of these pulps are also given in Table VII.

DISCUSSION

From Table III it is evident that the colour of the sulphate pulp from *Trema orientalis* became darker as the temperature of the digestion was increased from 142° to 162°C. An increase in the quantity of chemicals for digestion from 8% to 10% made the colour of the pulps darker but with a further increase to 12% the pulps became lighter in colour. Generally all the pulps reported in Table III were dark brown in colour.

The yields of the sulphate pulps decreased when the temperature of cooking was increased from 142° to 162°C. Lower yields of pulp were also observed when the quantity of chemicals for digestion was increased from 8% to 12%.

Generally the strength properties of the pulps were better in the case of digestions carried out at 153°C. than at 142°C. In the case of 10% and 12% cooks, there is no appreciable change in the strength properties of pulps when the temperature of digestion was increased from 153° to 162°C. The strength properties of pulps improved when the quantity of chemicals for cooking was increased from 8% to 12%.

In the case of soda pulps (vide Table IV) the colour of the pulp was generally less dark than the corresponding sulphate pulp. The brown colour of the pulp became darker when the temperature of cooking was increased from 142° to 162°C. With an increase in the quantity of chemicals for digestion, however, the colour became lighter.

As with sulphate pulps, the yields were high in the case of the soda cooks. The yield of soda pulps decreased when the quantity of chemicals for digestion was increased from 8% to 12%.

The strength properties of the soda pulps improved generally when the quantity of chemicals used for cooking was increased from 8% to 12%. In the case of 10% and 12% cooks, the tensile strength and tearing resistance were generally maximum when the digestion was carried out at 153°C. while the bursting strength and folding endurance were best in the case of 162°C. cooks.

The sulphate pulps had higher strength properties than the corresponding soda pulps. In both the processes, under the conditions studied, the digestion of the *kargol* chips with 12% chemicals (on the oven-dry basis of the raw material) at 153°C. for 4½ hours (vide Serial No. 8, Tables III and IV) gave pulps with highest strength properties. If higher yields are required, the digestion must be carried out under milder conditions than those recorded in Serial No. 8, Tables III and IV. From the results obtained in this investigation and from the experiments carried out on other hardwoods in this laboratory, it seems that the colour of the pulp can be made lighter by using higher quantities of chemicals for digestion.

The results of the pilot plant trials (vide Tables V and VI) indicate that pulps suitable for wrapping papers can be prepared from *Trema orientalis* by the sulphate or the soda process. The yields are quite high compared to bamboo sulphate pulp. Since *Trema orientalis* is short-fibred, the pulp from this wood will require to be admixed with a suitable quantity of a long fibred pulp such as bamboo pulp for the manufacture of wrapping papers on commercial paper-making machines. The strength properties of wrapping papers from *kargol* sulphate pulp are higher than those of wrapping papers from soda pulp. The strength properties of wrapping papers from bamboo sulphate pulp are superior to those of wrapping papers from *Trema orientalis*. The strength properties of wrapping papers from *kargol* and also from blends of *kargol* and bamboo pulps are, however, satisfactory.

CONCLUSIONS

1. Pulps in about 68% yield can be prepared from *Trema orientalis* by the sulphate or the soda process.

2. The colour of the *kargol* pulps is brown. The soda pulps are lighter in colour than the sulphate pulps. It seems possible to make the colour of these pulps lighter by carrying out the digestion with higher quantities of chemicals.

3. The strength properties of the *kargol* pulps are satisfactory. The sulphate pulps are, however, superior to the soda pulps in this respect.

4. Since *Trema orientalis* is short-fibred, the pulp from this species will require to be admixed with a suitable quantity of a long-fibred pulp in the manufacture of wrapping papers.

5. Wrapping papers made from *kargol* or from blends of *kargol* pulp and bamboo pulp were characterized by satisfactory strength properties.

Thanks are given to the Conservator of Forests, Utilization and Engineering Circle, Bombay State, and the Divisional Forest Officer, North Thana, Bombay State, for the supply of the wood for this investigation.

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TABLE III.—*Sulphate digestions of Trema orientalis*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals*	Concentration of chemicals	Digestion temperature	Digestion period†	Unbleached pulp yield*	Freeness of pulp	Drainage time	Basis weight
	%	g./litre	°C.	hours	%	c.c. (C.S.F.)	seconds	g./sq. metre
1	8	20	142	4·5	74·8	299	8·0	61·2
2	8	20	153	4·5	73·9	280	9·5	60·4
3	8	20	162	4·5	72·6	302	8·0	61·6
4	10	25	142	4·5	73·9	297	8·0	62·4
5	10	25	153	4·5	68·3	303	8·0	59·2
6	10	25	162	4·5	67·7	280	10·0	62·8
7	12	30	142	4·5	68·1	297	8·0	57·2
8	12	30	153	4·5	66·2	292	9·0	62·8
9	12	30	162	4·5	62·0	303	8·0	59·2

* The % is expressed on the basis of the raw material (oven-dry).

† This includes 1·5 hours required to raise the temperature of the contents of the autoclave from the room temperature to the maximum digestion temperature. The cooking was carried out at the maximum temperature for 3 hours.

and strength properties of standard pulp sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 58°F.

10	11	12	13	14	15
Breaking length (Schopper)	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding endurance (Schopper)	REMARKS
metres	%			double folds	
7330	3·2	62·1	47·9	160	The colour of the pulp was brown.
7710	3·4	55·4	48·1	290	The brown colour of the pulps was deeper than that of Serial No. 1.
7310	3·6	66·9	43·4	340	The brown colour of the pulp was deeper than that of Serial No. 2.
7870	3·5	67·6	48·7	430	The colour of the pulp was nearly the same as that of Serial No. 1.
8270	3·8	69·2	51·1	550	The colour of the pulp was slightly deeper than that of Serial No. 2.
8270	3·4	73·2	50·2	430	The brown colour of the pulp was deeper than that of Serial No. 3.
8300	3·9	73·2	54·9	600	The colour of the pulp was slightly deeper than that of Serial No. 1.
9170	3·9	93·0	59·1	1080	The colour of the pulp was deeper than that of Serial No. 7 but slightly lighter than that of Serial No. 5.
9290	4·0	76·0	60·3	770	The colour of the pulp was deeper than that of Serial No. 8 but lighter than that of Serial No. 6.

TABLE IV.—*Soda digestions of Trema orinetalis*

DIGESTION CONDITIONS AND PULP YIELDS

1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals*	Concentration of chemicals	Digestion temperature	Digestion period†	Unbleached pulp yield*	Freeness of pulp	Drainage time	Basis weight
	%	g./litre	°C.	hours	%	c.c. (C.S.F.)	seconds	g./sq. metre
1	8	20	142	4·5	78·1	300	8·0	58·4
2	8	20	153	4·5	78·1	320	6·0	60·4
3	8	20	162	4·5	76·8	305	7·0	58·4
4	10	25	142	4·5	75·9	310	7·0	57·2
5	10	25	153	4·5	75·9	310	7·0	58·4
6	10	25	162	4·5	73·1	310	7·0	62·8
7	12	30	142	4·5	71·3	310	7·0	61·2
8	12	30	153	4·5	71·3	310	7·0	60·0
9	12	30	162	4·5	67·6	310	7·0	60·8

* The % is expressed on the basis of the raw material (oven-dry).

† This includes 1·5 hours required to raise the temperature of the contents of the autoclave from the room temperature to the maximum digestion temperature. The cooking was carried out at the maximum temperature for 3 hours.

TABLE V.—PILOT

Digestions of Trema orientalis

1	2	3	4	5
Serial No.	Raw material	Total chemicals*	Concentration of chemicals	Digestion temperature
		%	g./litre	°C.
1	*Trema orientalis*	12	30	153
2	,,	12	30	153
3	Bamboo	12	30	162 for ½ hour and 153 for the remaining 3 hours

* The % is expressed on the basis of the raw material (oven-dry).

† The digestion period recorded in column 6 includes 1½ hours required to raise the contents of the digester from 70°C. to the cooking temperature. In case of bamboo, however, the temperature was raised to 162°C. in 1 hour.

and strength properties of standard pulp sheets

STRENGTH PROPERTIES OF STANDARD SHEETS CONDITIONED AT 65% R.H. AND 66°F.					
10	11	12	13	14	15
Breaking length (Schopper)	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding endurance (Schopper)	REMARKS
metres	%			double folds	
5380	2·0	53·5	39·0	20	The colour of the pulp was brown but lighter than that of Serial No. 1, Table III.
5970	2·3	52·2	38·8	70	The colour of the pulp was slightly deeper than that of Serial No. 1.
6290	2·3	58·3	37·6	70	The colour of the pulp was slightly deeper than that of Serial No. 2.
6300	2·5	62·5	37·7	90	The brown colour of the pulp was lighter than that of Serial No. 1.
6660	2·5	62·5	39·2	100	The colour of the pulp was slightly lighter than that of Serial No. 2 and deeper than that of Serial No. 4.
6260	2·6	60·7	42·8	120	The colour of the pulp was slightly lighter than that of Serial No. 3 but deeper than that of Serial No. 5.
6930	2·8	71·9	43·3	180	The colour of the pulp was lighter than that of Serial No. 4.
7300	2·8	70·4	47·0	280	The colour of the pulp was slightly lighter than that of Serial No. 5 but deeper than that of Serial No. 7.
6950	3·0	68·7	50·2	470	The colour of the pulp was slightly lighter than that of Serial No. 6 but deeper than that of Serial No. 8.

PLANT TRIALS

and bamboo and pulp yields

6	7	8	9
Digestion period†	Unscreened pulp yield*	Screened pulp yield*	REMARKS
hours	%	%	
$4\frac{1}{2}$	68·7	68·4	The sulphate process (NaOH = Na_2S = 2 : 1) was used.
$4\frac{1}{2}$	67·6	65·3	The soda process was used. The chips after digestion were harder than those in Serial No. 1.
$4\frac{1}{2}$	..	50·3	The sulphate process (NaOH : Na_2S = 2 : 1) was used. This pulp was used for making bamboo wrapping papers and also for admixing with soda pulp from *kargol* for making wrapping papers.

TABLE VI.—PILOT

Strength properties of papers from pulps described in Table V. Serial Nos. in this Table

1	2	3	4	5	6		7		8	
Serial No.	Freeness after the addition of size, etc.	Ream weight $17\frac{1}{2}'' \times 22\frac{1}{2}''$ -500	Basis weight*	Thickness	Tensile strength (Schopper)		Breaking length*		Stretch	
	c.c. (C.S.F.)	lb.	g./sq. metre	mils (1/1000 inch)	kg. breaking strain per cm. width		metres		%	
					Machine direction	Cross direction	Machine direction	Cross direction	Machine direction	Cross direction
1*a*	206	24·5	81·3	3·85	6·03	2·74	7420	3370	2·0	3·4
1*b*	245	24·7	83·2	4·35	5·26	2·60	6320	3130	1·9	3·4
1*c*	245	17·0	56·2	3·10	3·30	1·60	5870	2850	1·6	2·8
2*a*	216	22·0	73·5	4·30	4·20	2·34	5710	3180	2·1	3·3
2*b*	226	22·3	74·1	4·30	4·20	2·16	5670	2920	2·0	3·3

* For calculating this oven-dry weight of the paper was used.

PLANT TRIALS

correspond to the Serial Nos. in Table V. The papers were conditioned at 65% R.H. and 68°F.

9		10		11	12	13		14
Tearing resistance (Marx-Elmendorf)		Tear factor*		Bursting strength (Ashcroft)	Burst factor*	Folding resistance (Schopper)		
g.				lb./sq. inch		double folds		REMARKS
Machine direction	Cross direction	Machine direction	Cross direction			Machine direction	Cross direction	
42·8	50·4	52·6	62·0	38·3	33·1	90	50	This was made from 100% *kargol* sulphate pulp. Thinner paper could not be made as the stock was sticking to the first press. There were breakages while making this paper. A sample is appended.
52·1	61·7	62·6	74·2	35·7	30·2	80	50	This was made from a mixture of 70% *kargol* sulphate pulp and 30% bamboo sulphate pulp. The running of the paper was smooth. A sample is appended.
32·5	38·8	57·8	69·0	23·3	29·2	40	20	This was made from the same furnish as used in Serial No. 1*b*. The running of the paper was smooth. A sample is appended.
31·2	35·5	42·5	48·3	27·5	26·3	40	20	This was made from 100% *kargol* soda pulp. Thinner paper could not be made as the stock was sticking to the first press. There were breakages while making this paper. The colour of this paper is lighter than that of Serial No. 1*a*. A sample is appended.
45·4	51·6	61·3	69·6	28·1	26·7	80	30	This was made from a mixture of 67% *kargol* pulp and 33% bamboo sulphate pulp. The running of the paper was smooth. A sample is appended.

(*contd.*)

TABLE VI.—PILOT

Strength properties of papers from pulps described in Table V. Serial Nos. in this Table

1	2	3	4	5	6		7		8	
Serial No.	Freeness after the addition of size, etc.	Ream weight $17\frac{1}{2}'' \times 22\frac{1}{2}''$ –500	Basis weight*	Thickness	Tensile strength (Schopper)		Breaking length*		Stretch	
	c.c. (C.S.F.)	lb.	g./sq. metre	mils (1/1000 inch)	kg. breaking strain per cm. width		metres		%	
					Machine direction	Cross direction	Machine direction	Cross direction	Machine direction	Cross direction
2*c*	226	16·4	53·7	3·00	2·74	1·33	5100	2480	2·0	3·2
3*a*	256	22·2	72·8	4·70	4·77	2·11	6550	2900	2·6	4·6
3*b*	256	16·7	54·2	3·60	2·94	1·47	5420	2710	2·2	3·4

* For calculating this oven-dry weight of the paper was used.

TABLE VII.—*Strength properties of standard pulp sheets*

STRENGTH PROPERTIES OF STANDARD SHEETS

1	2	3	4	5	6
Serial No.	Freeness of pulp	Drainage time	Basis weight	Breaking length (Schopper)	Stretch
	c.c. (C.S.F.)	seconds	g./sq. metre	metres	%
1	259	10·0	59·6	4710	3·8
2	182	10·0	59·2	5830	3·7
3	197	8·0	58·0	5030	2·8
4	197	13·0	58·4	6480	4·9

PLANT TRIALS—(*concld.*)

correspond to the Serial Nos. in Table V. The papers were conditioned at 65% R.H. and 68°F.

9		10		11	12	13		14
Tearing resistance (Marx-Elmendorf)		Tear factor*		Bursting strength (Ashcroft)	Burst factor*	Folding resistance (Schopper)		
g.				lb./sq. inch		double folds		REMARKS
Machine direction	Cross direction	Machine direction	Cross direction			Machine direction	Cross direction	
31·3	36·7	58·3	68·3	21·5	28·2	30	10	This was made from the same furnish as used in Serial No. 2*b*. The running of the paper was smooth. A sample is appended.
77·6	87·3	106·6	119·9	40·5	39·1	460	150	This was made from 100% bamboo sulphate pulp. The running of the paper was smooth. A sample is appended.
54·5	61·9	100·6	114·2	29·3	38·0	250	40	This was made from the same furnish as used in Serial No. 3*a*. The running of the paper was smooth. A sample is appended.

made from the pulps prepared in the pilot plant trials

CONDITIONED AT 65% R.H. AND 68°F.

7	8	9	10
Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding endurance (Schopper)	REMARKS
		double folds	
114·1	40·1	150	This is bamboo pulp used for admixing with the *kargol* sulphate pulp for making wrapping papers.
67·1	43·0	200	This is sulphate pulp from *Trema orientalis* (vide Serial No. 1, Table V).
52·2	34·4	50	This is soda pulp from *Trema orientalis* (vide Serial No. 2, Table V).
118·6	50·5	590	This is bamboo pulp (vide Serial No. 3, Table V).

THE PROBLEM OF VEGETABLE TANNING MATERIALS

BY G. C. JOSHI

Six years ago the Ministry of Commerce and Industry held a meeting of Forest Officers from various States of the country to find a solution for developing indigenous sources of vegetable tanning materials. The effort at the Ministry level was, however, well timed with other responsibilities which came with independence. The well-known industrial and strategic importance of leather need hardly be stressed here and it naturally follows that for indigenous manufacture of leather, availability of tanning materials and their development is a *sine qua non* to maintain the balance of economy of an independent country. It is the purpose of this article to review the problem of tanning and vegetable tanning materials in the country and various measures that have been taken so far to find a solution for it.

Tanning is the process by which leather is manufactured from hides (of cattle and buffaloes) and skins (of sheep, goat and other ruminants and non-ruminants). In tanning the proteins of animal tissue are fixed, forming leather of commerce. As obtained from slaughter-houses (the usual source of raw material), these contain the entire outercoat of epidermis with intact hair, inner layer of dermis with its own protein fibres and superfluous tissue loosely hanging from the dermis, these may be blood, muscle fibres or fat. Leather is formed from dermis chiefly, consisting of white fibres (Collagen), yellow fibres (Elastin) and less known ground matrix (Reticulin). Generally the hyaline layer between epidermis and dermis is required to be retained as it gives characteristic look to the upper surface of leather. Hairs, epidermis and superfluous tissues are usually separated from the leather by scraping and treating the raw material with special chemicals which facilitate easy removal of these. One of such treatments is 'liming' after which the untanned material is thoroughly washed and is then ready for tanning. Fixation of proteins forming leather is a complex process in which the tanning material may enter the composition of the protein itself.

Two main types of tannage are known : (a) mineral tanning and (b) vegetable tanning. Some times synthetic chemicals may also be used to manufacture leather. The main process of mineral tanning is 'chrome tanning' utilizing chromates in the form of its sodium or potassium salts. The product from this process is a thin, fine, smooth, though less durable (in terms of wear and tear), leather taking high dye and polish. Chrome tanned leather is used for shoe uppers, wallets, and laminated clothing, etc. Sufficient deposits of chromium ores (chromites) are found in the country. Vegetable tanning utilizes 'tannins' obtained from bark, fruits, leaves or woods of a number of plants. The raw materials are either used directly or they are extracted for tannin concentrates. A large quantity of these materials is annually consumed by both local tanners as well as large scale manufacturers. The vegetable tannage leather is a tough, thick and durable material much priced for insoles, soles and a host of other leather goods. Much of the durability can be increased by mixed chroming, i.e., vegetable tanning as a pretreatment and final tanning with either vegetable tannins, as in the case of East Indian Kips or chrome tans. Leather of desired quality can also be produced by properly controlling the pH of the medium, biochemical control, tannin/non-tannin ratio and other conditions of the bran. Syntans or synthetic materials prepared from the by-products of various industries have been manufactured in India, and other countries to balance the strategic shortage of normal tanning materials. Their scope in this country is yet to be determined.

Of the two major tanning processes, vegetable tanning is most important not only from the view of products but also due to more important alternative uses of chromium products. Local tanners have been using vegetable tanning since time immemorial ; East Indian

Kips, fishing nets and country shoe leather are vegetable tanned in the scale of cottage industry. The Kips which are lightly tanned, yield excellent leather by further treatment and a large market exists for these in foreign countries. An idea of the importance of vegetable tanned leather manufacture *vis-à-vis* chrome tanned leather can be had from the following table :—

Year of production	Chrome tanned hides (manufactured in thousands)	Vegetable tanned hides (in thousands)
1948	1,087·2	1,958·1
1949	580·8	1,834·8
1950	495·6	1,514·4
1951	879·6	1,704·0
1952	650·4	1,478·4
1953 (up to October)	548·1	1,046·2

Tannins occurring in the raw tanning materials (forming minor forest products) are condensed aromatic glycosides falling broadly in two groups (a) of hydrolyzable (by acids and enzymes) tannins consisting of gallotannins from galls, ellagitannins from myrobalans, divi divi and teripods, valonia and oak barks and (b) of caffetannins covering pyrogallol tannins. Condensed tannins are not hydrolyzable and yield phlobaphenes or 'reds'. These were formerly classified by Perkin as catechol tannins (from Cutch, hemlock, quebracho and mangrove).

On reviewing the sources of vegetable tannins of this country one is surprised at the wide diversity of tannin sources and an extreme shortage of these in the country. Most of our supply of these materials was from South Africa in days prior to 1947. Figures for the years show that import an average was 40,000 tons of wattle bark (obtained from *Acacia mollissima* Wild), at that time costing Rs. 130/- to Rs. 150/- per ton. The price, however, shot to about Rs. 700/- per ton. The supply too, on severance of trade relations with that country was entirely cut off. At present import of these materials into India is from Kenya. One explanation for this problem of shortage may be sought in the statement that very little is known about tanning behaviour of these materials, and that indigenous sources could be better exploited by Indian tanners if these were known. It is natural that the tanner likes to pay a high price for reliable materials from abroad than to take risks with Indian materials of comparatively unknown properties. A significant work on this direction has been done by the Forest Research Institute, Dehra Dun in systematically collecting all scattered information about Indian vegetable tannin sources, and their properties*. The other part of the problem is perhaps real scarcity of these sources in the country. This phase of the problem has drawn the attention of the Government to a considerable extent.

Search for substitutes of South African wattle barks is fairly trying and needs active effort at the level of State Governments, Forest Departments and Scientific Institutions. Minimum demand of the country has been settled at a figure of 30,000 tons of bark in terms of wattle bark (tanning content 34%) per year. Indian tanning materials capable of replacing the imported material may be said to be babul (*Acacia arabica*), myrobalan nuts (*Terminalia chebula*), avaram (*Cassia auriculata*), mangrove and aonla. Ministry of Commerce and Industry reports show that sixty-five samples have been examined by various Government Institutions so far and a few more promising sources have been found. These are Karada

* Indian Forest Records, Vol. 1, No. 2, 1952.

bark (*Cleistanthus collinus*), black wattle (*Acacia mollissima*) and Indian Red wood (*Soymida febrifuga*). Of these, Wattle and *Karada* have been thought more suitable. With a minimum demand of 30,000 tons of bark per year as self sufficiency figure, the Government proposed a plan to solve the problem within shortest possible period. This plan of making the country self sufficient in vegetable tanning materials is very intimately connected with Forest Departments. A short review of the plan and the progress reported so far would facilitate to have a complete perspective of this problem.

A long term and a short term schemes were proposed and these are being actively pursued by many State Governments and most Forest Departments.

(*a*) The long term scheme aims at plantation of wattle (*Acacia mollissima*) on 8–10 years rotation so as to yield 4–5 tons of bark per acre. While the large scale plantation has been taken over by the Government of Madras, nursery and small scale field plantation experiments to find a suitable locality for the growth of promising plants are also being conducted by other States like Bombay, West Bengal, Uttar Pradesh, Punjab(I), Assam and Orissa. Annual forest reports of Madras Forest Department show that plantation of wattle has covered 15274 acres in upper Palnis (Kodai Kanal) and Mathurai Districts and 6,000 acres in Nilgiris. This covers 4,500 acres brought under plantation in 1952–53. A total of 60,000 acres is sufficient to yield the returns for minimum demand.

(*b*) The short term scheme covers examination of tanning samples all over the country. A few new materials were found suitable, of these *Cleistanthus collinus* bark, *Terminalia chebula* bark, and *Soymida febrifuga* wood have significant tannin content. Very little information is available about the tanning behaviour of these plants, whatever is known is summed up here :—

Karada bark (*Cleistanthus collinus*) – the tree is suitable for plantation in the country and plantation experiments are already in progress. The bark yields good leather.

Indian Red Wood (*Soymida febrifuga*) – the supply figures are not likely to meet the demand.

Myrobalan bark (*Terminalia chebula*) – the bark has a high and good tannin content but the tree is more valuable as a source of recurring yields of myrobalan fruits which find an export market as well. Whether the bark would be able to make good the loss suffered by closing the fruits is doubtful.

Avaram and babul have very low tannin contents compared to wattles and stand poor chances of preference.

It may be concluded from the above review that the problem of shortage of vegetable tanning materials may be partially met by the end of the planned period, i.e., when the plantation would begin yielding the raw materials. In the meantime a similar plantation of suitable trees elsewhere can be supposed to be more economical (a) from the point of view of transport and labour for collection of raw material and (b) decentralized economy of products. Regarding the (a) part of the problem a well planned effort can become a source of revenue to less developed areas where labour is cheap and land is less likely to be utilized for agricultural purposes.

SURFACE CRACKING OF *BAKLI* (*ANOGEISSUS LATIFOLIA*) AND *SAL* (*SHOREA ROBUSTA*) DURING DRYING

BY JAI KISHEN

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ABSTRACT

In this paper the phenomenon of cracking of wood during drying is discussed in brief. The moisture gradient on the surface at the time of cracking of wood, called the critical moisture gradient, has been directly determined for *bakli* and *sal*. An attempt has been made to show how far the critical moisture gradient is dependent upon the maximum strain perpendicular to the grain and the coefficient of shrinkage. The importance of this investigation to the seasoning of refractory woods has also been touched upon in the paper.

INTRODUCTION

The current kiln seasoning schedules, in general, are designed to prevent excessive degrade of the drying timber. The control of the degrade is obtained at the expense of increased kiln time. The experimental work done in the development of these schedules has been chiefly empirical and the results obtained though fairly satisfactory cannot be claimed as final. A correct seasoning schedule should be of minimum duration, should not impair the usefulness of the material and should give low degrade. In order to arrive at this schedule, an understanding of (a) the physical laws governing the rate of drying of wood, (b) the mechanical properties as influenced by temperature and moisture content and (c) the stresses causing the drying degrade, is essential

Drying of wood is a complicated phenomenon. Several investigators have attempted to deduce its laws but the phenomenon has thus far defied rigorous theoretical analysis. Of direct practical importance to the kiln seasoning problems are the data of Bateman (1) and his colleagues, which while proving that the drying of wood is in part a diffusion phenomenon, bring into evidence the considerable increase in the moisture diffusivity effected by the rise of temperature. So the application of high temperatures to kiln drying is not to be deprecated so long as such temperatures do not weaken the strength of wood or add to its degrade.

The study of the influence of temperature and moisture content on the mechanical properties of wood has become very important of late on account of its connection with air craft construction. A number of investigators (2, 3, 4, 5) have collected information on the subject in order to find the limiting temperatures allowable in kiln seasoning of various woods. The investigations of Greenhill (6) on fourteen Australian timbers show that the temperatures in kiln drying schedules are more likely to be limited by the degrade of the material rather than by any deterioration in its strength.

Of the various types of degrade suffered by wood, checking of the surface is common and occurs in the early stages of drying. It is caused by the shrinkage stresses. On account of its low perviousness, wood, which may be supposed to be in the form of a plank, dries from the outside inwards, giving rise to a moisture gradient along the depth. As the drying progresses below the fibre saturation point, the surface tends to shrink; but the more moist layers below prevent it from doing so. As a result the surface is left in a stretched state and under tension, and the lower layers under compression. On the surface the relative tensile strain S with respect to any lower layer also below the fibre saturation point, is given by

$$S = \alpha \cdot \Delta m \quad (1)$$

and

$$\Delta m = g\,x \quad (2)$$

where α is the mean relative strain per unit difference in the moisture content in the region Δm, Δm the difference in the moisture content, x the distance and g the mean moisture gradient between the surface and the layer below. Since the shrinkage is perpendicular to the grain, the accompanying tensile strain also occurs in the same direction. In severe drying, the surface is strained to the breaking point giving rise to checks travelling along the grain.

According to relation (i), the minimum difference of moisture content (Δm) between the surface and the lower layer, needed for causing the checking of the surface is

$$(\Delta m) = \frac{(S)}{\alpha} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

(S) is the maximum strain perpendicular to the grain. This minimum differential moisture content is constant for any timber for a given temperature and moisture content of the surface. But the checking will only be caused by it if the distribution of the moisture in the timber such that the lower layer does not lie outside the limiting depth from beyond which its effects cannot be communicated to the surface directly. The limiting depth, which should appropriately be called the depth action of the surface, is also a constant depending upon the physical and mechanical properties of the medium.

When a timber dries from the green state, the moisture gradients set up in it continue to increase for some time. The distance of the layer from the surface, the moisture content of which differs from that of the surface by the minimum amount (Δm) required for checking, decreases. Just as the distance becomes equal to the depth of action, the checking of the surface starts. The moisture gradient $\left(\frac{dm}{dx}\right)$ on the surface at this critical stage is given by

$$\left(\frac{dm}{dx}\right) = \frac{(\Delta m)}{(\Delta x)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

or

$$= \frac{(S)}{\alpha\,(\Delta x)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where (Δx) is the depth of action of the surface, throughout which the moisture gradient may be taken as uniform. This value of the moisture gradient is the minimum requirement for the production of the surface cracks and will be referred to as the critical moisture gradient.

The refractoriness of a timber is assessed from the severity of the drying condition in which the timber starts checking on the surface. This condition in turn depends mainly upon its critical moisture gradient, and to some extent on the rapidity of the moisture movement through the timber. The smaller the magnitude of these quantities, the milder will be the drying conditions required for producing surface-checking and consequently the higher will be the refractoriness. On account of its larger shrinkage and the presence of the planes of weakness of the rays, the tangential face of a timber is more refractory.

The kiln conditions in the early stages of the drying of a charge are regulated mainly to keep down surface-checking. But the operation cannot be precise as the information available on the factors responsible for the refractoriness of various timbers, is very little. Greenhill (7) has carried out tests on the strength and elastic properties of beech in tension perpendicular to the grain at various temperatures and moisture contents and has shown that the kiln drying of the species at 55°C. is likely to cause least checking as the unit deformation at this temperature is maximum. The development of the shrinkage stresses in the surface layers of some timbers during kiln drying has also been studied by Tiemann (8) and Rietz (9) in connection with "Stress Control Seasoning" and the latter has proposed a simple rule

indicating the stage beyond which cracking of the surface is not likely and consequently drying can be accelerated.

In the present work investigations have been carried out on the checking during drying of the tangential faces of *bakli* (*Anogeissus latifolia*) and *sal* (*Shorea robusta*), two very important but highly refractory Indian timbers. In part I of the work are given the details of the attempt made to derive the minimum differential moisture content necessary for checking. For the derivation, which is based on relation (3), the maximum tensile strain of the woods perpendicular to the grain in the tangential plane and the coefficient of tangential shrinkage have been experimentally obtained. In the calculation of the result it has been assumed that the effect of the internal compression perpendicular to the grain is small and the relative strain of the surface per unit differential moisture content is equal to the coefficient of shrinkage. The conditions chosen for the experiments are those usually met with in kiln drying.

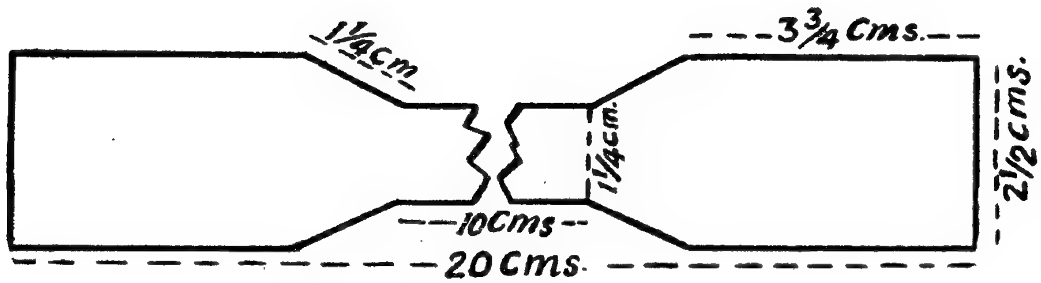
Part II deals with the determination of the critical moisture gradient for the species under the same conditions as above. Taking the minimum differential moisture content from Part I, critical moisture gradient from this part and remembering relation (4), the depth of action of the surface for *bakli* and *sal* has been estimated.

PART I

Maximum strain—The tests were conducted on the specimens of *bakli* and *sal* which had been brought gradually to 50°C. and moisture content in equilibrium with 80 per cent relative humidity. These conditions were selected because they were identical with those under which the green planks of both the species had been just found to develop surface cracks.

For getting the maximum strain perpendicular to the grain, several samples 20 cm. × $2\frac{1}{2}$ cm. × 6/10 cm. were cut from the green planks. Their length was perpendicular to the grain and broader face true tangential. These samples were conditioned at 50°C. and 80 per cent relative humidity. They were subsequently formed into test pieces of shape and size as in Fig. I, to ensure breakage at the reduced width.

FIG. 1. DETAILS OF A TEST PIECE



The pieces were conditioned again and then removed one by one to the universal testing machine (Buckton, 10,000 lbs.) in vacuum flasks kept with the pieces in the conditioning chamber. Each test piece was fixed in the clamps of the machine up to a depth of $3\frac{1}{2}$ cm. at each end. To measure the strain, a modified Lamb's Roller Extensometer constructed in the Timber Mechanics Branch, was attached to the narrow part of the test piece. The gauge

length was 5 cm. Between the clamps, the test piece was enclosed in a small cabinet. One end of the roller of the extensometer was coming out of a hole in the side of the cabinet and carried the mirror. The clamping of the test piece to the machine and fixing of the extensometer and the cabinet took about five minutes, immediately after which air at 50°C. and 80 per cent relative humidity was blown into the cabinet to recondition the piece. The air was coming from an electric blower. It bubbled through water at 44°C. where it was supposed to have been saturated. Then it passed through a copper coil immersed in an oil bath, the temperature of which was so regulated that when the air was led into the cabinet through a well-lagged delivery tube, it was at 50°C. Its relative humidity was 80 per cent (ref. any standard psychrometric chart). The temperature in the cabinet was read by a thermometer. The conditioned air escaped into the atmosphere from the hole for the extensometer roller and the small openings around the test place.

After waiting for about half an hour, the machine was worked and the pull was applied to the test piece at the rate of 0·05 inch per minute. The readings of the extension were taken at an interval of 25 lb. load till failure which occurred inside the cabinet perpendicular to the length in the narrow portion of the sample.

Coefficient of Shrinkage—Two sets of rectangular specimens of sizes 5 cm. × $2\frac{1}{2}$ cm. × $2\frac{1}{2}$ cm. and $2\frac{1}{2}$ cm. × $1\frac{1}{4}$ cm. × $1\frac{1}{4}$ cm. both of *bakli* ane *sal* were prepared out of the green material, care being taken that they were true radial and tangential. The specimens were conditioned in a constant humidity chamber at 50°C. and at various humidities ranging from 90 to 45 per cent of which one was 80 per cent. After this they were oven-dried. The moisture content of each piece at each humidity was obtained on the basis of its oven-dry weight. The tangential width was measured at each constant condition and after oven-drying. The data of shrinkage obtained from both sets of samples was consistent, shewing thereby that the conditioning was free of any tension set. The relation between the width and the moisture content is given for both the species, by straight lines below. Yo is the width in the oven-dry state.

$$\left.\begin{array}{ll} Y = Yo\,(\,1 + 0\cdot00484\,m\,) & \ldots\ \textit{bakli} \\ Y = Yo\,(\,1 + 0\cdot00455\,m\,) & \ldots\ \textit{sal} \end{array}\right\}\ldots\ldots\ldots (6)$$

The mean coefficient of shrinkage required for finding the minimum differential moisture content for cracking was derived by the following method of approximations.

First of all, the coefficient of shrinkage $\frac{1}{y}\frac{dy}{dm}$ for *bakli* and *sal*, was determined from the equation (6), at the equilibrium moisture content corresponding to 80 per cent relative humidity. This was further used to obtain the approximate value of the minimum differential moisture content. Calling it $(\Delta m)_a$, we get the mean coefficient of shrinkage a, from the relation

$$a = \frac{\int_{E.M.C.}^{E.M.C. + (\Delta m)_a} \frac{1}{y}\frac{dy}{dm}\,dm}{(\Delta m)_a} \ldots\ldots\ldots\ldots (7)$$

In table I are recorded the values for equilibrium moisture content at 50°C. and 80 per cent relative humidity, maximum strain at 50°C. and equilibrium moisture content, mean coefficient of shrinkage and minimum differential moisture content for surface-checking for both the species under test.

TABLE I

1	2	3	4	5
Species	E.M. Content% at 50°C. and 80% R.H.	Max. Strain at 50°C. and E.M.C.	Mean Coeff. Shrinkage	Min. Dif. M.C. $= (\frac{3}{4})$
Bakli ..	12·7	0·0109	0·00453	2·41
Sal ..	13·0	0·0189	0·00426	4·44

PART II

Critical Moisture Gradient—The following procedure was adopted for the determination of the critical moisture gradient of *bakli* and *sal*.

Tangentially sawn green planks of *sal* and *bakli* of size about $1\frac{1}{2}' \times 5'' \times 1\frac{1}{2}''$ with ends and sides coated with gloss oil paint, were dried in an indirectly steam heated internal fan type humidity chamber at 50°C. The starting relative humidity was 90 per cent which was gradually lowered in twelve hours to 80 per cent and was maintained there. At a time the chamber was charged with only two planks either of *sal* or *bakli*. After every fifteen minutes or so the planks were examined with a magnifying glass for a very short time and were returned to the chamber. At the appearance of the hair cracks which took about two hays, the planks were withdrawn from the chamber for the determination of the moisture gradient at the surface which could be done in the following two ways :—

By the first method the mositure gradient is given by $\frac{3}{1}(\mathrm{M} - \mathrm{E})$ where M is the mean moisture content of the plank, E the equilibrium moisture content and l half the thickness of the plank. This relation is based on the assumptions that (1) the moisture content of the surface is the equilibrium moisture content, (2) the moisture distribution along the depth of the plank is parabolic and (3) the moisture distribution is symmetrical. Since there was no justification for the third assumption this procedure was not followed. It was, however, realized though late, that the determination thus made could have served for checking the results obtained by the second method which was tried.

The second method was the usual one for finding the moisture distribution. From the plank on which the hair cracks had just appeared, a piece 2 cm. thick was sawn off. Again from the cracked face of the piece 5 sections each 0·4 cm. thick were cut along the depth with a fine band saw. The sides of the sections were trimmed off a little to remove the painted ends. The moisture content of each of the sections was obtained by oven-drying. It was actually the average moisture content of the section and was supposed to be situated in its middle. The data of the moisture content, thus derived, gave the distribution of the moisture in the planks below the cracked face at the time of checking.

The data was smoothed using quadratic or cubic expressions and the critical moisture gradient on the surface was derived by differentiating the expressions with respect to the depth and extrapolating. It is understood that this method involves several experimental errors. The exact time at which cracking took place was uncertain. The operation of cutting the moisture section and the time taken for it must have changed their moisture content.

Figure 2 shows the frequency distribution of the critical moisture gradients obtained from the tests on different planks of *bakli* and *sal*. In Table II are given the mean critical moisture gradient, and the depth of action of the surface for the two species.

TABLE II

1	2	3	4
Species	No. of observations	Mean Crit. Mois. Grad.	Depth of Action
Bakli	97	40·2 cm.$^{-1}$	0·060 cm.
Sal	118	60·2 cm.$^{-1}$	0·074 cm.

The ratios of the maximum tensile strains perpendicular to the grain in the tangential plane, minimum differential moisture contents required for the cracking of the tangential face and the critical moisture gradients of the species under test, are given in Table III.

TABLE III

No.	Property	*Bakli/Sal*
1	Max. Tensile Strain	0·58
2	Min. Diff. Moist. Content	0·54
3	Moisture Gradient	0·67

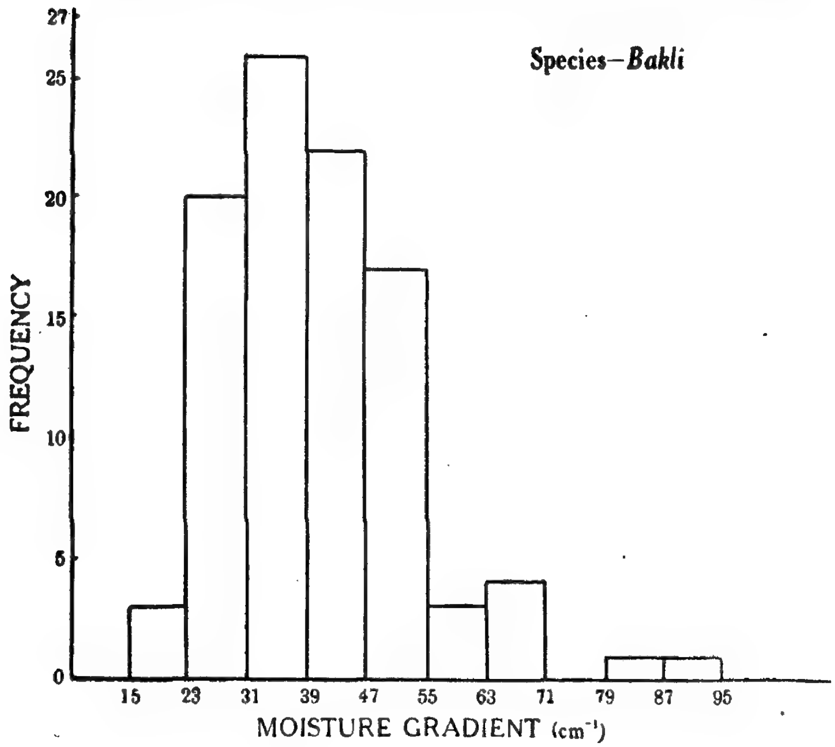
DISCUSSION

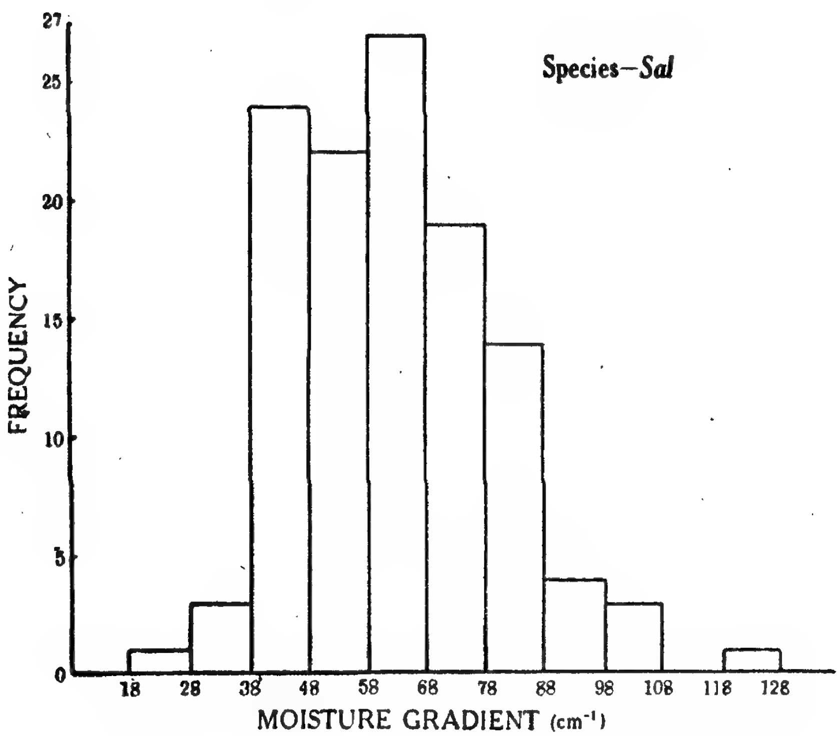
The explanation of the cracking of wood attempted in this investigation is not claimed to be rigorously exact. What it is intended is to emphasize that there is a distinct quantitative parallelism between the critical moisture gradient, the maximum tensile strain and the minimum differential moisture content as shown in Table III. So it may be profitable to pay attention to the physical and mechanical properties of the timbers, especially the refractory ones, while searching for their correct kiln seasoning schedules. The effort is likely to shorten the prolonged search usually based on trials and errors.

It would have been interesting to deduce the critical moisture gradient of the timbers under test from their mechanical properties. To do this we have to determine the depth of action of the surface by some direct method, which has not been attempted.

The histograms in Fig. 2 show that the dispersion in the distribution of the critical moisture gradients of *bakli* and *sal* as derived in Part II, is wide. Some dispersion is natural in a material like wood but mainly it may be attributed to the experimental errors involved in the determination of the critical moisture gradients. Their mean values in table II should, however, be more accurate as the number of observations taken is fairly large.

FIG. 2. HISTOGRAMS FOR CRITICAL MOISTURE GRADIENT





Attention must also be drawn to the point that the faces of the planks used in the cracking experiment could not be perfectly tangential. Besides producing some dispersion this might have slightly biassed the recorded values of the critical moisture gradients towards the higher side.

The equilibrium moisture contents of *bakli* and *sal* at 80 per cent relative humidity being practically the same, has considerably simplified the investigation.

In conclusion the author takes the opportunity to express his thanks to Mr. V. D. Limaye and Mr. Mohd. Hasnain of the Timber Mechanics Branch and Dr. K. R. Nair and Mr. R. P. Bhargava of the Statistical Branch for their help in the completion of the work. The author is particularly thankful to Mr. M. A. Rehman, Officer-in-Charge, Wood Seasoning Branch for the encouragement received throughout this investigation and Mr. Dwarka Prasad of the Wood Seasoning Branch who took most of the observations.

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TREE – THE TEACHER

BY MAHENDRA PRAKASH, M.SC.

"Ye are all leaves of one tree, the fruit of one branch..........
..................The world is but one, and mankind its citizens".

Scriptures and ancient books in every land abound in reference to vegetation and trees. Their example has been invoked to impart morals to the common man. From ages tales have been told to children depicting trees to give them lessons on morality and behaviour. Forests and trees have influenced thinking men in their formation of philosophies. Sages have sung of them, men have worshipped them.

Trees have played an important role in the evolution of humanity. Greatest benefactors, friends, teachers and preceptors, trees are linked up with our existence from cradle to grave. They have aroused in us the sense of aesthetic and instinct of love, service, sacrifice and harmony. The sages have taken refuge and shelter in the lovely sylvan bowers, where they have found solace, peace and even salvation. Our scriptures, literature, folklore and fables are full of illustrations to prove that the trees are the embodiments of majesty, grace, beauty, fortitude, forbearance, un-alloyed love and sacrifice.

Unity preached through trees—The moral that 'Union is strength' is preached in Sanskrit literature.

"The Forest tree that stands alone,
Though huge, and strong and rooted fast,
Unable to brave the blast,
By furious gusts is overthrown.

While trees that growing side by side,
A mass compact together form,
Each sheltering each, defy the storm,
And green from age to age abide".

Honour to the enemy—That a man should show honourable behaviour even to his enemy is taught in the ancient Hindu scriptures.

"A tree refuses not its shade
To him who comes to hew it down".

and also—

"A hero hates not even a foe,
Whose deadly bow is 'gainst him bent,
The sandal tree with fragrant scent,
Imbues the axe which lays it down".

The struggle of life—Life is a struggle. Men have been asked to live "as trees do". Poet S. N. Pant writes :—

"Bear the hammer strokes of struggle
Patiently, do not be afraid to face life,
Grow like trees, take care of the means,
Do not bother about the ends".

Edwin Arnold in his famous book "Light of Asia" expresses the same idea :—

"And all should live as trees do, so much spring,
Such and such rains and frosts, so much winter times,
And then dead leaves, with may be spring again,
Or axe stroke at the roots".

Men are thus advised to face life boldly, and take things as they come without complaining—

"How well 'twould be if we could thus conceal
The aches and pains and sorrow that we feel".
—*Jack Gibey.*

The transience of life—The life is a bubble. Our existence on this planet is for a short period. Man should therefore make his stay in this world as useful to others as possible.

"Oh; Trees
I believe in your beauty;
Though your falling leaves
Sing to me of the things that die".

Lord Buckhurst in the 16th century advised us upon the temporariness of human existence as taught by the trees—

"It taught we well, all earthly things ne born
To die the death, for naught long time may last".

Seigfried Sassoon puts a philosophy in lines :—

"Grow on my lawn, embodying time
The transience of this lifetime teach".

Cast off evils as trees do their leaves—For a man to be wise, he should cast off his evil tendencies just as trees cast off their leaves. Ancient Hindu saints have compared men entangled in desires to the tangled masses of bamboos in a forest.

Look at your own faults—Man is full of faults, yet he looks at the shortcomings in others neglecting his own faults and defects,

"Thou mark'st the faults of other men,
Although as mustard seeds minute,
Thy own escape thy partial ken,
Though in size a Bilva fruit".

In Dhampada, Budha compares flowers without scent to the agreeably spoken but fruitless words of one who does not act accordingly. A Latin proverb advises us to "judge a Tree by its fruit, and not by its leaves", and according to St. Matthew—'by their fruits ye shall know them'.

From small beginnings great things grow—Importance of little things in life is stressed by Edwin Arnold—

"Great tree grows from two soft leaves
To spread its shade afar".

Just as 'tall Oaks from little acorns grow', Robert Browning in 'A Forest Thought' tells us of the big tree of the future :—

"A seedling springs - the forest tree
In miniature.............
....
Which shall one day foil the hurricane".

Tree-planting - an inspiration—Tree-planting is an expression of faith in a worthy enterprise, no matter how small be the beginning. By planting trees we plant happiness, and make an effort to secure for the unborn generations the fruits of labour invested to-day. Lin Yutang in his book, "My people and my country" records his reflections of a tree:—"The outline of every tree expresses a rythm resulting from certain organic impulses, the impulse to grow and reach out toward the sunshine, the impulse to maintain its equillibrium, and the necessity of resisting the movement of the wind. Every tree is beautiful because it suggests these impulses and particularly because it suggests a movement towards somewhere, a stretching towards something".

He who plants a tree is a servant of God. He loves others besides himself. Various qualities have been attributed to trees and men have been asked to inculcate them, as peace from Birch, strength from Pine, tenderness from Beech, endurance from Oak. One can learn

so much from trees. They are symbols of strength, beauty and service. The teacher, friend and servant. A tree is a symbol of a higher life. J. R. Lowell asks you a question :—

> "Who does his duty ?" – Too complex to be answered,
>
> "But he, I venture the suggestion,
> Does part of his that plants a tree".

Myself a tree—Looking to the universality of the trees, their brotherhood, their sacrifice, no wonder, any thinking man would say :—

> "I read and sigh, and wish I were a tree
> For sure then I should grow
> To fruit or shade". (*George Herbert*).

Similarly, Wilfrid Thorley wants himself turned into a Tree :—

> "I feel as though a fairy could
> Turn all my body into wood,
> My hair to leaves, my hands and feet
> To branches full of blossoms sweet,
> The more I lie, the more this me
> Turns from itself into a tree".

God in trees—Wordsworth mentions of the 'divine vitality' of the trees. As "channel of God, the trees carry the 'elixir of infinite love, syrup of infinite power'". Nancy Price glorifies the tree and feels its oneness with God :—

> "Man owes most things to trees
> Each day with tree he lives,
> Until that final hour
> When quiet in tree he lies.
> Yet day by day
> Man wounds and hacks
> Thee in the Trees".

There is the 'Kalpa-Vriksha' lodged in the heaven. In Atharv-Veda there are hymns in praise of 'Aranyani', the Forest Goddess. A great forest tree has been termed as "Vanaspati", the king of the Forest. Deodar is called as 'Kedara' and 'Shiva' as 'Kedarnath'. The tree according to Hindu scriptures is ten times as important as a son.

Protect the tree—For all the great gifts the trees have showered upon us we owe them a sense of gratitude, but the selfish man mercilessly hacks them down. One can visualise how dry, insipid and cheerless this world would be, devoid of all its sylvan heritage if we did not acknowledge the debt, and took pledges, one and all, to protect them all, and to plant as many as we can.

According to Manu, who compiled codes of Hindu life and made rules concerning the administration of justice, "a fine must be imposed for injuring all kinds of trees in exact accordance with their usefulness ; thus is the rule".

The trees therefore, from times immemorial, have inspired us, have taught us, have sheltered and have protected us. From cradle to grave man lives so intimately with the trees. It is our bounden duty to protect what exists and to plant as many as we can for posterity.

TESTING OF WOOD PRESERVATIVES

PART II*

Boliden Salts

BY M. C. TEWARI AND J. N. PANDE

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The Boliden salts[1] were developed in Sweden by the Boliden Mining Company, for protection of timbers against deterioration due to various biological causes. Sweden, it may be mentioned, has plenty of coniferous timbers of low durability, and utilizes them on a very large scale for most of its structural work after preservative treatment. Sweden has also plenty of white arsenic, a reputed insecticide. Therefore, work on the development of an indigenous wood preservative was taken up early in 1933, and in 1938 a composition, B.I.S.[2] was developed containing arsenic and zinc as toxic ions and chromium for fixation of these in timber. This composition resembles Ascu which was developed at this Institute (1933) except that the less toxic ion zinc was used in the former in place of copper. However, a recent formulation of the Boliden salt S25, contains arsenic, zinc and copper together with chromium. The B.I.S. was subjected to both laboratory and field tests particularly in Sweden and U.S.A. from 1936 to 1941 using coniferous timbers. The results are reported to have been satisfactory[3]. The S25 is expected to give even better results.

In India there is a very great scope for the utilization of water soluble preservatives, particularly of the fixed type for the treatment of timber where the odour and oily surface presented by creosote are objectionable, e.g., in house and ship-building timbers, transmission and telegraph poles ; in timbers for high-way bridges, decks and sides ; in packing case timbers and timbers for furniture, tool handles, etc. Service conditions in India are very severe, and preservatives that have proved a success in the temperate countries cannot be automatically assumed to give equally satisfactory results here. They should establish their efficacy through satisfactory service tests. So far water soluble preservatives like Wolman Salts, Celcure and Ascu have been tested here and only the last two have been found to be quite good. Of these two, Ascu has been used on a large scale for over 20 years now, and it can be considered as an efficient preservative containing both the insecticidal arsenic ion and the fungicidal copper ion. The main difficulty in the general use of this preservative is due to the uncertainty of steady imports of arsenic pentoxide, one of its important constitutents, now obtained from the Scandinavian countries. Since the Boliden Salt is manufactured in Sweden, it is considered that there may not be any difficulty in the availability of this preservative, at least in peace time. The testing of the preservative S25 under Indian conditions, in the laboratory and in the field, was therefore taken up.

The laboratory tests were confined to leaching of the preservative from treated timber, corrosion on mild steel and brass plates by the preservative and inflammability of treated timber. In the field tests, several species of treated timber specimens and bamboos of different sizes have been installed in the ground (in the open) or in structures under cover. The results of these tests, excepting that of the inflammability tests already published[4], are reported in this paper.

LEACHING TESTS

The leaching tests were carried out substantially as described earlier[5]. *Chir* and *sal* blocks (5·1 × 2·6 × 1·6 cm.) were impregnated after air seasoning with two concentrations of the Boliden Salt S25. These were then subjected to leaching after a lapse of one week and

* Part I was published in the September 1952, issue of our Journal.

three weeks at room temperature (18·5° to 21°C.) and at 40°C. For this purpose 4 blocks at a time were placed in a ground glass stoppered bottle containing 200 cc. of distilled water and subjected to about 20,000 shakes in a shaking machine. At the end of this operation, the chemicals leached out of the blocks by the water added to the bottles, were quantitatively estimated. For purpose of leaching at 40°C., the shaking machine was placed inside a thermostatically maintained chamber at that temperature. This method proved more efficient than that desecribed earlier[5], wherein the bottle containing the blocks and the distilled water was heated at 40°C. for about 6 hours in a suitable water bath and then subjected to shaking at room temperature. The results of these leaching experiments are reported in Table I.

CORROSION TESTS

The corrosion tests were carried out by immersing well-cleaned and tared mild steel and brass plates in a 4% solution of Boliden Salt S25, in distilled water which was maintained at room temperature for one week. At the end of this period the plates were removed from the solution, thoroughly washed with water and their surface very carefully cleaned of adhering materials and dried and weighed. The percentage loss in weight is attributed to corrosion by the preservative. Details of these results are reported in Table No. II.

GRAVEYARD TESTS

For the graveyard tests, different species of air-dried specimens of size 24 × 2 × 2 inches, and 2 feet long round sapwood pieces of sal (*Shorea robusta*) were impregnated under pressure with two different concentrations namely, 4% and 2% preservative solution in water. For accelerated field tests, *semul* (*Bombax malabaricum*) and *chir* (*Pinus longifolia*) veneers (6″ × 2″ × 3/8″) were impregnated with the same concentrations mentioned above by the Full-cell process. After air seasoning for a period of three weeks, these specimens were laid in the yard, in the open ground up to half their length along with untreated controls. The results of inspection of these specimens after a period of about a year are reported in Table III. Some structures were also installed using treated timber (*chir* and sapwood of teak) and bamboos. These are under observation.

RESULTS AND DISCUSSIONS

The results of leaching tests, vide Table No. I, indicate that in the case of *chir* specimens, copper was practically completely fixed, the leached amounts being only in traces. As regards dichromate, about 5 to 7% was leached out under all conditions. It is seen that 1·3 to 1·81% of Arsenic pentoxide was leached out when 6·035% solution was used for treating and when the specimens subjected to leaching after one week. However, it is interesting to note, that when the concentration of the treating solution was reduced to 3·017%, Arsenic was practically completely fixed, even when leaching was carried out at 40°C. after one week of seasoning of the specimens. In the case of Zinc sulpahte, the leaching has been sufficiently heavy ; about 15 to 20% being leached out when the concentration of the treating solution was 3·017%. These results indicate that among the toxic ions Copper is best fixed, next Arsenic and last of all Zinc.

The results are somewhat different in the case of sal specimens. Both Copper and Chromium get completely fixed under all conditions of leaching. Arsenic is leached between 3 and 7%, when leaching was carried out after one week and the concentrations of the preservative were 6·035% and 3·017% respectively. In the case of Zinc, the fixation has been

rather poor; about 41·38% being the maximum amount leached out at 40°C. corresponding to the 3·017% concentration of the preservative. It may be recalled, that in the leaching tests with copper-chrome-boric composition also, it was noted that while Chromium was completely fixed in sal specimens, it was not so in *chir* specimens – the causes leading to this, therefore, require careful investigation so as to introduce similar conditions in timbers less amenable to satisfactory fixation.

It may be concluded, that if the major portion of Zinc, which gives this preservative better fire-resisting properties compared to Ascu (results already reported) is to be properly fixed under the rather severe climatic conditions experienced in the tropics (high temperatures and heavy rainfall), the manufacturers of this preservative would do well to take adequate steps to change their formula. Perhaps addition of more dichromate may be necessary.

The results on the corrosion tests are reassuring in that the corrosion on either mild steel or brass is not heavy.

The field tests, no doubt, indicate that while the controls have been destroyed within one year, the treated specimens are all sound in the ranges of absorptions experimented with. But it should be noted that after all the specimens have been under observation only for about a year. Therefore, their behaviour should be watched with keen interest in the next few years or so, particularly because the leaching tests, as already reported, have not been quite satisfactory as far as fixation of Zinc is concerned. And, in addition, in the field of wood preservation, preservative treatment of timber cannot be considered economical unless a service life of 15 to 20 years in the open is obtained.

The cost of the preservative at about Rs. 147 per cwt., which is rather high and requires careful re-examination by the manufacturers if it is to earn popularity. At present the preservative is imported in liquid condition and loss due to leakage is often experienced. Further, in liquid condition the transport charges are also unnecessarily increased. The manufacture of the preservative in India by utilizing locally available ingredients except arsenic pentoxide also requires careful examination, as it would reduce further the cost of the preservative.

The authors take this opportunity to express their grateful thanks to Dr. A. Purshotham, Officer in Charge, Wood Preservation Branch, for his guidance in these investigations.

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TABLE I

Results on Leaching in water of chir and sal specimens (5·1 cm. × 2·6 cm. × 1·6 cm.) treated with Boliden Salt S25

Original % Conc. of the preservative	% of Sodium dichomate leached out		% of Copper sulphate leached out		% of Arsenic pentoxide leached out		% of Zinc sulphate leached out		Total % of preservative leached out	
	at room temp.	at 40°C.	at room temp.	at 40°C.	at room temp.	at 40°C.	at room temp.	at 40°C.	at room temp.	at 40°C.
LEACHED AFTER AIR-DRYING FOR 1 WEEK										
Species CHIR										
6·035	6·49	6·91	Tr	Tr	1·3	1·81	9·63	12·21	5·19	6·23
3·017	6·72	7·77	Tr	Tr	Nil	Nil	14·4	19·5	6·27	8·1
Species SAL										
6·035	Nil	Nil	Tr	Tr	2·79	2·92	20·97	24·07	6·94	7·88
3·017	Nil	Nil	Tr	Tr	5·04	7·37	37·87	41·38	12·54	14·25
LEACHED AFTER AIR-DRYING FOR 3 WEEKS										
Species CHIR										
6·035	5·0	5·55	Tr	Tr	Nil	Nil	9·16	8·79	4·2	4·27
3·017	5·51	5·62	Tr	Tr	Nil	Nil	9·7	14·88	4·53	6·06
Species SAL										
6·035	Nil	Nil	Tr	Tr	Nil	Nil	12·75	16·8	3·71	4·9
3·017	Tr	Tr	Tr	Tr	Nil	Nil	21·86	30·58	6·36	8·8

Range of Room Temperature 18·5°C. to 21·°C.

TABLE II

Corrosion effect of Boliden Salt S25 on mild steel and brass

Solution used :—4% in water

Identification Nos.	Metal used	Initial weight gms.	Final weight after 1 week's immersion in cold solution gms.	% Loss in weight	
1	Steel	24·60	24·51	0·366	Average 0·371
2	,,	25·75	25·65	0·388	
3	,,	25·01	24·92	0·360	
1 (small)	,,	14·58	14·52	0·411	Average 0·433
3 ,,	,,	15·97	15·91	0·376	
4 ,,	,,	15·60	15·52	0·513	
1	Brass	26·08	26·01	0·268	Average 0·394
2	,,	26·68	26·59	0·337	
3	,,	27·76	27·60	0·576	

TABLE III.—SUMMARY OF CONDITION OF SPECIMENS TREATED WITH

Specimens treated under pressure

Species of timber		No. and size of specimen	% concentration of Boliden Salt in water	Absorption (Dry Salt) lb. – cu. ft.			Date of laying
				Max.	Min.	Average	
Pinus longifolia (sapwood)	..	6a	4	2·04	1·93	1·97	26–11–52
Bombax malabaricum	..	6a	4	1·20	1·02	1·08	,,
Pinus longifolia (sapwood)	..	6a	2	0·96	0·91	0·94	,,
Bombax malabaricum	..	6a	2	0·62	0·55	0·58	,,
Pinus longifolia (sapwood)	..	6a	Controls	..	..	..	,,
Bombax malabaricum	..	6a	,,	..	..	..	,,
Shorea robusta (sapwood)	..	6b	4	2·29	1·0	1·67	28–11–52
Do.	..	6b	2	0·90	0·43	0·69	,,
Do.	..	1b	Controls	..	..	..	,,
Amoora wallichii	..	4a	2	0·091	0·022	0.044	13–1–53
Engelhardtia spp.	..	6a	2	0·52	0·13	0·33	,,
Sapium spp.	..	6a	2	0·90	0·84	0·86	,,
Vatica lanceaefolia	..	4a	2	0·66	0·47	0·56	,,
Drypetes spp.	..	6a	2	0·54	0·47	0·50	,,
Amoora wallichii	..	6a	Controls	..	..	..	21–11–52
Engelhardtia spp.	..	6a	,,	..	..	..	,,
Sapium spp.	..	6a	,,	..	..	..	,,
Vatica lanceaefolia	..	6a	,,	..	..	..	,,
Drypetes spp.	..	6a	,,	..	..	..	13–1–53
Bombax malabaricum	..	6c	4	1·57	1·19	1·30	10–12–52
Pinus longifolia	..	6c	4	1·75	1·48	1·57	,,
Bombax malabaricum	..	6c	2	0·56	0·43	0·49	,,
Pinus longifolia	..	6c	2	0·69	0·59	0·63	,,
Bombax malabaricum	..	6c	Controls	..	..	..	,,
Pinus longifolia	..	6c	,,	..	..	..	,,

Note :—a—Rectangular specimens of size 2′ × 2″ × 2″.

b—Round specimens 2′ long.

c—Veneer specimens 6″ × 2″ × ⅜″.

*—Attacked by fungus also.

BOLIDEN SALT S25 AND LAID DOWN IN THE GRAVEYARD AT NEW FOREST
by Full Cell Process

Date of last inspection	Summary of the condition of specimens last inspection					Average life months
	Number sound	Number slightly attacked	Number moderately attacked	Number badly attacked	Number destroyed	
17–12–53	6	..	..	..	..	..
,,	6	..	..	..	..	..
,,	6	..	..	..	..	..
,,	6	..	..	..	..	..
,,	..	..	1	..	5	..
,,	..	..	..	..	6	9
,,	6	..	..	..	..	..
,,	6	..	..	..	..	..
,,	..	..	..	..	1	8
,,	4	..	..	..	..	..
,,	6	..	..	..	..	..
,,	6	..	..	..	..	..
,,	4	..	..	..	..	..
,,	6	..	..	..	..	..
5–1–54	..	6*	..	..	..	..
,,	..	..	..	3	3*	..
,,	..	..	..	..	6	13
,,	..	..	5	1	..	..
,,	..	4*	2	..	..	..
18–12–53	6	..	..	..	..	..
,,	6	..	..	..	..	..
,,	6	..	..	..	..	..
,,	6	..	..	..	..	..
,,	..	2	..	..	4	..
,,	..	2	4	..	..	..

JOURNEY THROUGH A SAL TREE

BY LAKSHMI KANT PANDEY, B.SC. (AGRI.), A.I.F.C.
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I took out my kerchief, wiped the beads of sweat from my forehead, adjusted my spectacles by pushing the frame more tight on the nose and looked up to get the view of the tip of the magnificent Sal tree that stood before me. Ah ! the very sight restored the strength in my tired limbs. The spring had given its new presents and the high branches now covered with beautiful white flowers presented a picturesque view against the clear blue sky. My eyes got fixed on its huge stem and massive radiating branches. Unknowingly, a smile crept over my lips. I took out my tape and made my way towards it.

I bowed first for the respect, then repeatedly to get through the bushes. The stem was thickly laden with mosses. I scratched it, fixed the end of the tape and started going round. The nails in my boot slipped over a glittering piece of rock and bang ! .... my head struck against something, and the whole world revolved round and round.

I winked, scratched my head and, yes, I was alive and awake. I felt, I was going up in a lift, a sensation like that. Slowly and slowly my eyes got used to the surroundings. Cool diffuse light was falling all round. I was seated in a *dingy* which was flowing with the current, a rudderless, at times striking one bank then the other. It was a canal perhaps taken through a tunnel, and not only one, but plenty of them ran parallel to one another and many cargo boats saying "Raw materials", with definite destinations on them were going the same direction my *dingy* was flowing. The walls of the canal were beautifully decorated with different sizes of geometric shaped translucent bricks and at places were fitted with glowing gems. This canal had given off many branches at intervals. Suddenly with a quick motion my *dingy* entered one of the side branches and I had to practically lie down to save my head getting struck against the upper wall of the tunnel. I did not know when I crossed this low-roofed tunnel, and now this canal broke into numerous finger like channels. I passed through the main gate which controlled the inflow of water and there on the main gate was written "To Leaf Nagar", and the gate itelf was named 'Pitiola'. Before I could appreciate the charming sight, my *dingy* ran around with a sudden jerk giving a violent sensation in my body.

I landed into toe-deep water of the field, anchored my *dingy* and straightened my back. But lo ! my head struck against something. I looked up. Ah ! it was a nice green muslin cover to protect the inhabitants from direct rays of the sun. I fancied at the workmanship when I saw the different designs made on it and especially those eye-like 'skylights'. Really it was a masterpiece work.

And now I ran my eyes to find any native of the place and there they were working in the field. The workers clad in green clothes were busy at their job. I was wonder-struck to see the discipline among them ; at one time they raised both the hands in the air to catch something which they mixed in the canal water flowing in small reservoir, while another set of them were stirring the liquid and evaporating at atmospheric temperature – might be using solar heaters. It was a funny sight to see people silently catching something invisible from the atmosphere and pretending to be hard at work. "A perfect asylum" I murmered and was just turning towards my *dingy* when one of them came running with some liquid from the evaporating pan. I took the jug and looked towards him. He directed me to drink. Though

I was hesitant I sipped a little and my eyes brightened, new energy rushed in my veins and smile played on my lips. I drank to my tummyful. It was a brilliant sugar syrup, so fresh, so tasteful and aromatic that even a little remembrance puts my head in rythmic motion.

* * * * * * *

I let my *dingy* flow in some other direction while my mind was entangled in realizing the mystry of nature, the great marvel I had seen, and the thing I had tasted; how easily and with what speed they manufactured sugar: then my *dingy* took another turn and this time the city of 'Floribunda' stood before me. The settings were all different. It was bright and painted with all charming colours nature could produce. Every nook and corner was wonderfully decorated. Roads, paths, parks resturants were all full of gay young males and females. A day of festival it looked. Every moment roars of laughter rung in the sky while groups of couples danced and cheered one another. I lost myself completely in their fun and was soon entangled with one of the sweet sixteens. The beauty told her name 'Miss Pistil', and that now she has come of age, she must have her life partner. I thought fortune had smiled on me and without losing a single moment poured out voluminous praises to her beauty and extended my hand for her choice, assuring her wonderful honeymooning. She lowered her eyes, smiles and blushed. My eyes closed automatically with pleasure. I took a deep breath and the sweet odour in which she was enveloped maddened me with joy.

And I heard a little humming at a distance. A number of planes approached the city. They came nearer and nearer and were distinguishable. They were no more planes but beautifully decorated honey bees and butterflies. They landed and out came handsome youngmen in same colour and fashion. The whole crowd got stirred up and these new arrivals took hold of young girls and crept into parks and resturants. I looked out for my 'Miss Pistil' but she was already shamelessly embracing one and before I could reach her, they disappeared behind some enclosure. I closed my eyes and opened again. I sat down and placed my chin in-between my palms. My plans were already shattered, hopes crushed and life looked an endless desert. I moved my head again with expectation but the field was deserted. Only the honey bees were busy collecting sweets and other presents.

I moved slowly and with hung head towards my *dingy*. Every step I took pinched my heart. I was befooled. I reached my *dingy* and lifted the anchor and bid farewell to the land. I lost myself in thought. I had no idea how and where I was going. Only thing clear is that my *dingy* banged against some dark object and.........the whole world moved faster till I could feel clearly the Flora lying on my face and I on my bed.

SCIENCE NOTES

I

Frost damage to *Pinus caribaea* Morelet, the Slash Pine, an exotic to New Forest

This tree is a native of the southern States of the United States of America and British Honduras. It is one of the most rapidly growing and early maturing of all eastern forest trees in the U.S.A. Because of its capacity to produce wood pulp, fuel, bamboo and naval stores as well as its adaptability to moist sandy soils in its range, it has been extensively planted on the States. Best grown trees attain heights up to 150 feet and diameters up to 3 feet. It has been successfully grown in South Africa at various elevations and can stand more intense heat and cold than our chir pine (*Pinus longifolia*). Its habitat is characterized by short mild winters with some frost on about 120 days in the year. Ice and snow are seldom seen.

The chief value of slash pine is for turpentine production, but the tree also yields the heaviest and strongest of all pine woods of the U.S.A., wood which is extensively used for constructional purposes, bridges, trestles, docks, buildings, beams, piles and joists, flooring and railway carriage building. The sapwood, suitably treated with preservatives, is used for railway sleepers, while it is also used for paper pulp, which gives good grades of brown wrapping paper, and finally its wood is also an excellent fuel.

This tree might prove very useful for planting up the *chanders* of South Kheri and Pilibhit divisions where so far no useful tree has grown satisfactory on account of frost.

In its home the tree grows typically on the poorly drained flats and borders of swamps but it can also grow on better drained soils provided they are adequately moist. It does not grow on sandy, dry soils.

In its home, natural regeneration of the tree is easy to obtain and it is stated to colonize abandoned cultivation but, in Dehra Dun, where it has been raised with success, we find so far no evidence of this ability, although it is definitely premature to say so because the tree has just started bearing cones. The seeds are normally very fertile, viability being up to 90%, but the seeds imported to Dehra Dun from Maryland (U.S.A.) had a viability of only 41%.

The tree, like chir pine, can be raised by direct sowing of the seed, and it is likely that line sowings in *taungya* would be a very suitable method ; but transplanting nursery seedlings is preferred, the small plantation in the F.R.I. estate having been raised by planting potted plants. The trees in the New Forest plantations, now 15 years old, were 59 feet high and 2 feet 7 inches in girth when last measured, about a year ago.

Wild pigs cause considerable damage to young slash pine trees in New Forest by gnawing off their bark all round, sometimes causing their death. Rabbits also bite off the tops of young seedlings. Of some interest in connection with the growth of the tree is the occurrence of certain twig abnormalities in the young pine crop found growing in the Silviculturist's Research Garden. The abnormality consists in characteristic bending or sometimes severe crooking of the shoots of a previous year (Fig.). The plants are being watched by the author year after year for the last five winters and more, but this abnormality occurred only during 1951 and 1953 when temperatures nearing zero continued on 3 or more consecutive nights *and that in the latter part of January* when the leaf buds which are beginning to swell are

subjected to low temperatures for long periods. It has to be added that similar low temperatures in December, when the plants are in midst of their winter rest, do not produce the same results. For example although temperatures nearing 0°C. prevailed on 4 consecutive days from 23rd to 26th December 1949, this produced no crooking of the twigs in the ensuing growing season.

The severity of the distortion noted (Fig.) varies from a simple crook or offset, usually near the middle of a terminal shoot, to a pronounced S-shaped crook which, in many instances, is acutely bent or distorted in more than one place. The same injury was not found on chir pine (*P. longifolia*) which is a frost hardy tree whose plantation adjoins that of the Caribean pine nor was it found in the older plantation of the same pine found in the neighbourhood whose trees are about 50 feet high and therefore well above the level of stagnation frosts.

The presence of the injury in the young plantation which is surrounded by older plantations of chir pine and broad leaved trees in a locality where stagnation frosts are common, indicates a climatic factor as the cause of this abnormality.

Daily Minimum temperatures, December 1949 to January 1953

Date	Dec. 1949	Jan. 1950	Dec. 1950	Jan. 1951	Dec. 1951	Jan. 1952	Dec. 1952	Jan. 1953
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	42·0	47·7	41·0	36·6	51·1	40·0	42·8	51·0
2	41·8	48·8	41·8	38·0	48·0	47·6	41·2	39·5
3	40·0	41·4	43·6	37·8	46·4	39·7	43·5	40·0
4	39·8	41·6	42·6	39·0	46·3	41·0	44·4	40·7
5	39·4	42·2	46·6	41·3	46·9	41·6	45·0	44·0
6	39·5	40·0	42·0	41·5	47·9	41·8	44·3	43·0
7	43·4	36·9	40·0	46·9	47·3	54·0	44·0	48·0
8	41·6	40·4	38·2	39·4	47·3	51·1	43·3	44·1
9	50·4	37·7	40·0	36·8	46·0	41·1	41·2	46·4
10	43·2	38·3	41·0	39·8	44·8	42·8	41·5	47·0
11	39·0	41·6	39·0	45·0	46·0	41·0	41·6	51·0
12	41·5	45·3	37·5	46·8	43·0	38·8	43·2	48·9
13	48·4	42·3	36·8	48·5	44·0	45·4	44·8	45·0
14	40·7	44·0	35·7	45·0	43·4	46·3	46·4	44·0
15	39·0	42·6	36·0	43·0	42·0	43·4	45·6	50·3
16	38·5	46·3	38·5	48·3	40·7	43·5	47·0	45·2
17	41·8	48·1	44·0	39·8	43·4	41·5	46·9	37·2
18	40·8	47·7	42·7	39·0	42·0	41·4	45·0	36·4
19	39·4	50·8	45·2	46·7	41·0	47·2	43·0	45·2
20	37·0	53·8	47·0	40·8	41·5	45·8	43·6	41·8
21	34·4	42·8	42·2	43·0	43·7	48·2	42·5	41·7
22	42·0	41·6	40·3	36·8	45·0	46·0	45·4	41·5
23	37·4	40·0	41·0	37·6	44·7	46·0	48·2	36·4
24	37·2	48·0	43·4	39·0	45·8	43·0	43·0	36·0
25	36·8	47·4	46·5	39·0	46·7	43·0	46·8	36·8
26	37·0	46·2	39·5	42·0	47·4	41·0	40·7	45·0
27	41·0	43·8	46·0	41·0	47·8	46·0	39·0	45·3
28	41·0	44·5	39·3	43·0	48·0	44·6	40·2	44·0
29	39·8	51·3	38·0	42·3	45·4	51·0	47·7	39·5
30	41·2	49·6	42·8	43·0	47·3	47·0	50·8	41·5
31	42·0	44·6	38·3	44·6	48·0	49·0	..	44·0
Average	40·5	44·4	41·2	41·7	45·4	44·5	44·1	43·2

Search of the literature has disclosed three illustrated accounts of similar distortion and its origin : Hartig, Rhoades and Stone, have reported a wilting of young shoots immediately following a sub-lethal frost injury to Scotspine and Japanese Red-Pine (*Pinus densiflora*), respectively. Some time later the wilted shoots became again turgid and curved upwards resulting in a permanent bend or crook as the tissues hardened. Internally the injury resulted in a typical frost ring (double ring) which, near the base of the shoot, is well within the secondary wood ; higher on the shoot this zone is in the youngest formed wood and the outermost cells of the pith, reflecting the various degrees of development at the time of injury.

These descriptions agree very well with observations on the present material including the double rings. This agreement, considered with the other evidence mentioned, perhaps rules out every kind of injury excepting frost as the cause of injury.

The temperature records which are available in New Forest estate reveal that near freezing temperatures prevailed on three consecutive days from 24th to 26th January 1953. Although the minimum temperature reported was 36°F. local temperatures in the level open plantations may well have been 1 to 2°F. lower. Hence the frost leading to the injury described above, very probably occurred on one of the above dates with 25th January as the most likely date. A date earlier than 24th January is not probable because of the early growth stage at which the injury occurred, as seen by the relative position of the bend within the shoot. Low temperatures occurring near the end of January following usually warm days results in crooking very near the base of the new shoots. January is often the coldest month of the year in New Forest.

Injuries of this nature appear to be rather rare, and arise under conditions of low temperature which are not severe enough to kill the twig but are yet sharp enough to cause some visible injury at the time when the young shoots are not well emerged. I have observed this only twice during the last five winters. Rhoades observed it only once during his wide studies while Sorauer has referred only to the example described by Hartig. Nothing of the sort is mentioned by Day and Peace in their study on experimental production of frost injury. Belyea and Mac Aloney's description of crooking belongs specifically to the up curve of lateral branches which replace dead terminal shoots. Nevertheless, such injury has been occasionally seen in nature without being assigned to any definite cause. In the present instance the shoots have normally continued their growth whether they are apical shoots or those belonging to the side branches. In no case was death of the shoot encountered.

A lot of experimental work has been done on the problem of frost injury but, from the foresters' point of view it is unfortunate that much of it has been done on agricultural and horticultural crop plants.

It is a matter of doubt as to how much of the damage to forest trees is due to actual frost and how much to acceleration of transpiration caused by wind. Wind causes excessive transpiration during periods when soil is frozen and the intake of water is thereby being impeded.

In Saxony (Germany) most of the winter damage to Norway spruce is held to be due to low temperatures but in the Black forest (Schwartzwald) damage is held to be due to excessive transpiration because here temperatures never fall very low. Day and Peace suggest that in America both the above causes may contribute to frost damage. The above observers have stated that low temperatures occurring in autumn and spring are more responsible for frost damage than the same temperatures occurring in winter. Susceptibility, therefore, seems to be lowest in winter but rises throughout the spring, the same being highest during the period when growth is starting. These observations are based on the present author's own work on trees in the Grafrath Forest Research Garden near Munich (Germany) and it is possible that the periods may vary for other plants.

The physico-chemical properties of the cell which affect the reaction of plants to low temperatures and how they act have been the subject of various investigators in the past. It has been argued by various authors that frost hardiness can be caused by : (1) low moisture content in twigs, (2) increased moisture content, i.e., just the opposite of No. (1), (3) increased sugar content, (4) increase of oil at the expense of starch, which is what the present writer found for Scotspine in Bavaria, (5) high osmotic pressure, and osmotic pressure is highest in winter, (6) low concentration of soluble salts, i.e., just the opposite of No. (6). The

factor which has been best correlated with frost resistance is an increase of the water held by the colloids in the cell ; greater pentosan content has indicated increased hardiness. Very good relation between increased cell permeability and increased frost resistance has also been found.

When a plant is exposed to temperatures below the freezing point ice is formed, but, on account of the dissolved substances in the cell sap, ice formation takes place only after the temperature has fallen several degrees below zero. Undercooling also takes place in plants and may enable them to suffer temperatures 2 or 3 degrees below the freezing point of the cell sap without ice formation setting in. What is of importance to us, under New Forest conditions, is not, however, this ice formation because temperatures below the freezing point are not normally found here, but the fact that some plants can be damaged by temperatures near to and *yet well above* the freezing point. As this can occur there seems every reason to believe that damage may take place in hardy plants below freezing point which may not be due to ice formation ; in other words ice formation is not necessarily the cause of frost damage. It is suggested that this injury is due to physiological disturbances resulting in the accumulation of toxins. Sorauer working on *Begonias* has suggested that the injury is due to sudden changes in the tension of cell walls and consequent structural damage.

The mechanism of frost injury is as yet little understood. The injury may be chemical, caused by disturbances in nutrition or accumulation of toxic substances, it may be chemico-physical owing to the colloidal structure of the cell being affected by cold or it may be mechanical resulting from rupture of the tissues by the formation of ice. It is likely, too, that more than one of the above causes may lead to the injuries commonly noticed on the plants. Environmental factors by increasing or decreasing the causes noted above may influence the severity of the damage. The moisture content of the soil may also affect the osmotic pressure of the cell sap and increase or diminish frost injury, as also manuring which can alter the cell contents. Practically no work has been done on this subject in India.

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II

On Loranthus Control

Summary—(*Loranthus pulverulentus*, Wall. found on *Dalbergia sissoo*, has been effectively controlled by injecting small doses of copper sulphate and Fernoxone into the attacked trees. The note describes details of the method).

It is well known to foresters and orchard growers that Loranthus is a destructive parasite. It is, at best, a great nuisance and at worst it causes wholesale destruction of plantations.

There are about sixty species of Loranthus in India (Hooker). Many kill fruit trees ; among them Mango is one of the great sufferers, the offending Loranthus in this case being *L. longiflorus*. The variety *falcata* Kurz., of this species is stated to parasatise on 110 kinds of trees among them being teak, *Acacia* sp., *Albizzia* sp., *Melia* sp., etc.

Among the forest trees of India, a great many important ones suffer from the attacks of the parasite, such as teak, rosewood, *Dalbergia sissoo, Terminalia tomentosa, T. paniculata, Shorea robusta, Pterocarpus marsupium, Xylia xylocarpa*, etc., etc. The valuable sandal tree is also often attacked. The wattle plantations in the Nilgiris of South India and the *Gmelina arborea* plantations of West Bengal are notorious examples of the destructive propensities of this parasite. Teak and rosewood plantations, too, suffer a lot, while in natural forests *sissoo* is often found attacked.

The Loranthus attacking *sissoo* in the Sub-Himalayan forests of North India has been tentatively identified as *L. pulverulentus*, Wall. by the Forest Botanist. This species has been described by Duthie as follows :—

> A robust branch parasite ; branchlets and young leaves clothed with white fugacious mealy tomentum.......*Racemes* solitary or in fascicles, ½ to 2½ in. long ; bracts minute. *Flowers* about 1 in. long on the long pedicels, scurfily white tomentose,...... *Flowers*. December–June.

Known method of control in forestry practice—The commonly known method, and one which is laborious and sometimes impracticable while dealing with large areas of forest, practised since almost a century, is to climb the attacked trees and lop the infected branches. It is important that the branches are cut sufficiently low so that all vestiges of the haustorial system of the Loranthus are eradicated from the host branch ; even if a small vestige remains behind, it regrows with renewed vigour and soon becomes as damaging to the tree as before. Working Plan Officers all over India generally prescribe this as the only known remedy ; they often say that this process should be repeated at frequent intervals. This operation is, in short, impracticable in most places – too costly, troublesome and inadequately effective.

Research on Loranthus control has, unfortunately, not been taken up seriously anywhere in India. About 17 years ago, while trying out the effect of injections of some phytocidal chemicals namely, salts of mercury, copper, etc., on the spike disease of sandal, the writer had injected copper sulphate into spiked sandal trees. This chemical had no effect on the virus, but what surprised him was the fact that large bushes of Loranthus which were on the sandal trees under observation dried up ; and the bushes failed to resprout.

Bearing this in mind, in 1950 the writer injected copper sulphate into several *sissoo* trees which carried Loranthus bushes on them. A couple of months later the leaves of the Loranthus began to slowly wilt, shrivel up and die. The trees were left under observation till 1952, but the dead Loranthus on them did not resprout. The treatment was repeated in 1953 on more *sissoo* trees, and with similar successful results. It was, thus, confirmed

that copper sulphate is a selective phytocide, toxic to the parasite but not so to the host. However, its action is slow. "Fernoxone" (a 2-4D preparation) was administered to a few trees ; to some others a dose of copper sulphate was administered *which was later followed up by a small dose of Fernoxone*. The results of these two treatments were spectacular ; the leaves of Loranthus started to shrivel up within about a week of the treatment (See Fig.), and in a couple of months the following results were recorded :—

Tree No.	Diam. in.	Number of Loranthus bushes found	Number alive	Number dead
1	15·2	8	2	6
2	12·2	4	..	4
3	11·2	1	..	1
4	11·5	2	1	1
5	15·0	3	2	1
6	8·7	7	..	7
7	13·0	2	..	2
8	12·0	1	..	1

Treatment technique—Two rows of holes are bored along the periphery of the tree with a small carpenter's timber auger. These holes are made to project downwards and inwards into the sapwood at an angle of 45°, to reach down to the heartwood. The number of holes made varies with the girth of the tree, the distance between one hole and its next being about 6 in. The holes of the two rows are made to alternate.

Dosage—The quantity of the chemicals injected into each hole was :—(1) copper sulphate, ¼ oz. (2) Fernoxone, 1/32 oz.

Season—Cursory observations indicate that under Dehra Dun conditions the treatment is likely to be most effective during March–April when the leaves begin to reappear on *sissoo* trees. The treatment is less effective in autumn than in spring.

It is important to note that heavier doses of both copper sulphate and Fernoxone are likely to kill the tree itself. Caution has, therefore, to be exercised in treating the trees. An overdose may sometimes result in the complete defoliation of the tree, which is followed by resprouting a little latter. Severe doses – say double that given above – may prove fatal to the tree itself.

The treatment is easy, cheap and so far as the existing observations go, very effective. A workman can treat as many as 20 to 30 medium sized trees with the chemicals in a forenoon. Once killed, the parasite does not reappear for a period of at least 4 years.

We have probably found in copper sulphate and "Fernoxone", therefore, *cheap, efficient* and *effective* treatments against Loranthus. Work is being continued on other parasites, including also fungi.

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THE PLANTATION DRILL

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INTRODUCTORY

Grow more trees is the order of the day. There is the great festival of *VANA MAHOTSAVA* coming once in a year in drab, dripping days to goad the people to plant trees. The importance and urgency of grow more forests have been recognised by the Central and State governments and afforestation occupies a prominent place in the galaxy of the National Plans.

In recent years *Plantation* has assumed extra-ordinary significance as a subject, as a trade and as a science.

Afforestation projects are vast and stupenduous. The task is likely to fall upon young forest officers most of them fresh from the colleges. This article is therefore, intended to serve the young officers as a "refresher" of what they might have learnt in colleges with a sprinkling of the author's personal impressions.

SUMMARY

Raise the plantation first in your mind's eye then translate it into the field.

Prolonged drought, water-logging, bad soil, bad drainage and deadly pests are a serious menace to the success of plantations. There is indeed not much man can do to combat effectively these natural evils specially where large scale afforestations under forest conditions are involved and where the cost factor and the topography preclude the tender provisions of rearing plants under garden care.

But the natural scourges have often been blamed far more than is fair. There are other more potent causes for failure which generally remain unmentioned. Bad choice of site and species, use of bad seeds, inadequate soil working, wrong time and technique of seed sowing and planting and post planting delinquencies are more often directly answerable to poor successes than the natural phenomena.

To ensure reasonable success, great emphasis should be laid on the promptitude, punctilio and perfection of the various plantation operations. Edaphic and climatic vagaries can largely be reconciled or even curbed if we just take care of the factors which are well within our means of control.

In the plantation cosmos it is wrong to gauge the importance of various individual operations with comparative prejudice. All operations singly and unitedly are equally influential. A bad seed may not germinate but a good seed too cannot germinate or survive under adverse conditions. Similarly, even though soil working and the seeds sown might be very good the plants would still perish due to the sowings having been done at the wrong time – either too early or too late in the season or due to the plants being subsequently stifled by weeds. For success there must be a happy unison of all contributary forces.

Sowing and planting are an exacting task and call for immaculate planning and a scientific approach. They are essentially a drill and demand training and rehearsal. Each man engaged must know his job, and he should do one thing at a time. It is highly inadequate to wake up with the advent of rains and rush forth haphazardly with the plantation work and unleash a force of untrained and disorderly workers.

The entire series of operations should be conducted in a drill sequence. The following are some of the tips. There is nothing new about them, however, except that special emphasis has been laid on the elementary needs for proper planning, competent organization, timely operations and thoroughness of each operation. The indications made are for localities inaccessible to irrigation.

Soil Working—Soil working should be thoroughly done. The trenches or pits should be deep and wide. The better the soil working the more the chances of success.

Soil working should as a rule be completed well in advance of the sowings preferably in the cold weather preceding the sowing when the ground is soft and easy to work.

Fencing—The area must be fenced if it is prone to inroads of domestic animals. It would be ideal to raise game-proof fencing but I lay no emphasis on this in view of the widespread need for intensive economy.

It is a false economy to leave plantations unfenced and exposed. Fencing is more than half the battle won. It is better not to get involved in plantation schemes than to execute them clumsily. Plantations without protection are a gamble. It is unsafe to gamble with plantations. A plantation without fencing is a slip-shod affair and if success is the cherished goal fencing must be recognized as the primary need. If funds do not permit fencing then the area of plantation should be curtailed to provide for fencing. A smaller area succeeded is manyfold better than a large area failed.

Seed—The stock of seeds must be subjected to thorough scrutiny before sowing. In many cases the simple cutting test will reveal whether the seeds are field-worthy.

Some seeds such as *Neem*, *Gutel*, *Jamun*, Sal, *Mango*, *Mohwa*, Camphor, Sandal, etc., lose viability very quickly and they must be sown fresh. The common complaisance that the seeds were collected a week or so ago is grossly pernicious and should be firmly ruled out. To be on the safe side such seeds must be sown absolutely fresh, in any case not more than a day or two after collection if the seeds are available locally. For such seeds coming from outside sow promptly. Putrefaction in starchy seeds sets in rapidly and even though the inside kernel may not always show pronounced stain, longer storage invariably diminishes considerably the vitality required for germination and subsequent development. Seedlings from stale seeds are distinctly etiolated from the very beginning and invariably court a cringing death.

The fallacy of sowing abortive seeds is abominable – it is indeed a criminal neglect.

Programme of operations—The local officer-in-charge must be furnished with a detailed and fool-proof programme of operations sufficiently in advance of the zero hour. The programme should normally indicate :—

(i) Division of the area into operational zones.
(ii) Staff responsible for the operations in each zone.
(iii) The species to be sown and the sowing order.
(iv) Species to be raised from existing nursery stocks and the time of planting.
(v) Targets for completion of sowings and plantings.
(vi) Alternative species for sowing and planting if any of the given species runs short of supply.
(vii) A forecast showing probable dates of :—
  (*a*) Filling back of pits or trenches.
  (*b*) Sowings.
  (*c*) Resowing in case of failures.
  (*d*) Planting.
  (*e*) Weeding.
(viii) A forecast of expenditure.

Filling back of pits or trenches—The heap of sun-baked soil outside the pit should not be filled back until it is thoroughly soaked with rain and partly dried afterwards. This will enable the outside soil and the gaping pit to release the first spurt of lethal gaseous heat. It has been observed that seeds sown in dry filled pits suffer vastly due evidently to excessive heat that suddenly generates inside the pit after the initial soakage. The harm is probably greater if the soakage is superficial and inadequately intermittent just before the sowing.

Sowing—The time for sowing should ordinarily synchronise with the outbreak of regular rains. Delayed sowing deprives the seed of the optimum soil temperature and the maximum benefit of rains for development.

All sowings should as far as possible be completed within a day or two, however, large the area to be sown may be. Sowing must be carried out concertedly. To achieve the target the plantation area should be divided into a number of smaller operational zones each under a sowing squad. All sowing squads must function simultaneously in their respective zones.

Sowing is a precesion operation. It is important that each bed receives the seeds properly and in the manner desired. Care must be taken to ensure the correct depth of sowing required by different seeds.

Each sowing squad should be divided into as many self-contained sowing-units as is necessary. Each sowing squad should take up a complete set of rows at a time.

As an insurance against faulty sowing or stampede which might result in some of the pits remaining unsown (in a vast area where the organization is not perfect such omissions often occur), the following arrangements should be made :—

> Split each sowing unit into two batches – one consisting of two men and the other of one man only. The first batch of two men will do the sowing. Actually, of the two men engaged only one does the sowing while the other carries the seeds. The first batch will not cover the seeds after sowing but will move on to the next bed for sowing. The second batch will immediately leap-frog and cover the seeds with soil after satisfying that they have been correctly sown. Make sure that the man does not forget to give the lucky tap before departing to the next bed.

To make the process of sowing mechanical and speedy, seeds of different species should be kept separately. Do not permit mixing of seeds. Each seed should be carried in a separate pouch or container. To save the sowing-man from fumbling for seeds, he should be acqainted with the order of seeds carried by the seed-carrier. A multi-chambered tin bowl with an arched suspender should serve as a good device to keep seeds separately in a compact container.

To maintain continuity of sowing in each zone maintain a link-service of seed-feeders. The seed-feeders should collect seeds from the field store and keep on supplying to various sowing units. At no time should the work be dislocated for want of seeds. Or else it would mean delay and delay in plantation work is simply not wanted.

Failure of first sowings—Should any of the first sowings fail or not come up well, do not waste time on undue expectancy. If a seed does not germinate within a reasonable time or germinates phlegmatically, act quickly and resow. It always makes a safe provision. But remember to resow in such a manner as not to disturb much the original sowings.

Planting—Planting of entire transplants and cuttings from the nurseries is always safe when the rains have fully established and drought is unlikely. But the plantings should not be unduely delayed once the rains have set in, otherwise the plants will not receive the maximum benefit of the rains and will not get established to face the post-monsoon tribulations.

Employ careful hands on planting. Plant immediately after taking out the stock from the nursery. For planting entires and stumps choose a cloudy day preferably drizzling. Do not forget to nip the extra leaves from the entires to minimize loss of moisture through transpiration.

Weeding—The time and frequency of weeding should be determined locally according to the need. But the weedings must be thoroughly done. The surface soil should be broken and loosened adequately to improve aeration and all weeds within $1\frac{1}{2}$–2 feet of the flanks should be eliminated.

Stray branches of trees and shrubs should be pruned to relieve baneful supression.

Cleanings—Theoretically, the density of seedlings in the rows should be eased out in the following winter. But, in practice this is dangerous in view of the long spell of dry weather and heat of the ensuing summer which are a doughty challange to the puny plants in their first year of existence. It is therefore safer to defer the cleaning until the plants are one year old.

Supervision—It is said plants respond phenomenally well under the kindly look of the gardner. The progress of plantation work and its subsequent conduct should be steadfastly inspected. Inspection must be done with eyes wide open. Many an ill is remedied by a timely gaze. Take personal interest in the welfare of the juvinile vegetation and take delight to see the emerald stalks rise out of the brown dust.

Control of expenditure—Expenditure needs to be drastically controlled. It must be remembered that extravagance in plantation is a sad commentary on one's achievement. Credit lies in getting work done cheaply. All items of expenditure must, therefore, be well guarded.

And finally there is that soft subtle element known as luck. Sometimes despite your very best, the rains may abruptly fail or incessant copious downpour may cause violent flooding and stagnation resulting in unexpected reverses to your efforts. Such natural calamaties are to be deeply deplored but they should not be permitted to assail you with regret or despondency. You had done your best.

MATHEMATICAL EQUATION FOR DETERMINING THE STEM TIMBER FORM FACTOR OF *TECTONA GRANDIS**

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Introduction—The most accurate method of obtaining the volume of the wood in a sample plot is by clear-felling the plot and measuring the volume of the felled trees; but this is very seldom practicable. So, sample trees are measured and the volume of the crop is determined by Schwappach's 'height and form factor curve' method. The selection of sample trees is done in such a way that each sample tree represents the mean of one of the groups into which the crop is divided. The diameter of each sample tree should be as close as possible to the diameter equivalent to the mean basal area of the group which the tree represents. The tree should conform as closely as possible in height, bole form and shape of the crown, to the ideal mean tree of the class it is supposed to represent. But, this selection of sample trees is difficult, if not impossible, to carry out correctly in practice, because it is liable to personal bias.

However, sample trees as close to the ideal tree as possible are selected and measured for total height, diameter at breast height, stem timber and stem small wood volume along with some additional measurements for bark thickness, form quotient, crown length, crown width and other useful informations. Usually sample trees are selected and measured from thinnings done within the plot or in its surround; but difficulty arises after some time because then suitable sample trees are not easily available both within the plot and its surround. An alternative method is to measure the heights of the standing trees and use a form factor table, provided there is one which could be safely used.

In this paper, an attempt has been made to determine the form factor for trees of different dimensions and age growing under different locality conditions, and thus provide a method by which the volumes of standing trees can be estimated from measurements of d.b.h. and tree heights only. The diameters at breast height of all the trees in a sample plot are easily recorded and the heights of standing trees covering the complete range of diameters are measured either directly by climbing the trees or by means of an Abney Level. A Height/Diameter Curve is then drawn and the heights for mean group diameters are read off from it. The stem timber form factor can be read from the mathematical curves or worked out from the equation proposed in this paper.

Form factor is the coefficient by which the volume of a cylinder, having the same length and basal area as the tree, has to be multiplied in order to obtain the volume of the tree, i.e., $V = S \times h \times f$

where V = volume in cubic feet,
S = basal area in square feet,
h = total height in feet, and
f = form factor.

Owing to variations in the growth, such as bole formation, forking, branchiness, form of the crown, and also the age of tree and the site quality, form factor cannot be the same for all trees or even for the same tree in different localities. *Tectona grandis*, being one of the most valuable timber trees of India, has been taken up for this study and for preparing stem timber form factor curves applicable to all site qualities over quite a wide range of diameters for which felled sample trees are difficult to obtain.

* This paper was submitted for the Howard Medal, and later received for publication during April, 1954.

Data utilized—The d.b.h. and stem timber form factor data were taken from the teak sample plot records and arranged qualitywise in order to eliminate the variations in the crop due to locality factors and the consequences of dissimilar silvicultural operations in the past. The data were grouped in 1 inch diameter class, totalled and averaged qualitywise as shown for site quality I in appendix (I). As trees below 7·5 in. d.b.h. do not normally contain any timber volume, the first diameter class ranges from 7·5″ to 8·0″. The data for higher diameter classes were inadequate but still they have been utilized to check the accuracy of the formula evolved. A glance at appendix (I), shows that there is a great variation in the stem timber form factors of the same diameters in a group. This is bound to happen as the stem timber form factor of a tree depends on: (i) its total height, (ii) form of bole, (iii) height of first green branch from the ground, (iv) form of the crown, and several other factors. An attempt was, however, made to reject the abnormal points by statistical tests, but this did not prove very helpful. (The main test applied was the rejection of data for which the deviation exceeded twice the standard deviation).

The equation evolved—Different curves were tried and finally from the shape of the curve drawn out of the basic data, the equation of the hyperbolic curve appeared reasonably suitable. A close approach to the actual from the estimated form factor was obtained by some modifications of the hyperbolic curve of the form $y = \frac{x}{a + bx}$ and the formula in the final form was

$$y = \frac{x - x_1}{a + bx} + y_1 \qquad \text{where}$$

y = the required form factor,

x = the diameter at breast height,

a, b, are two constants and x_1, y_1 the initial observed values of x, y respectively. Appendices (2) to (5) contain average values for d.b.h. and stem timber form factor and show full calculations for deriving computed values of the latter. The values obtained for the various constants for different site qualities along with the final equations are given in Table 1.

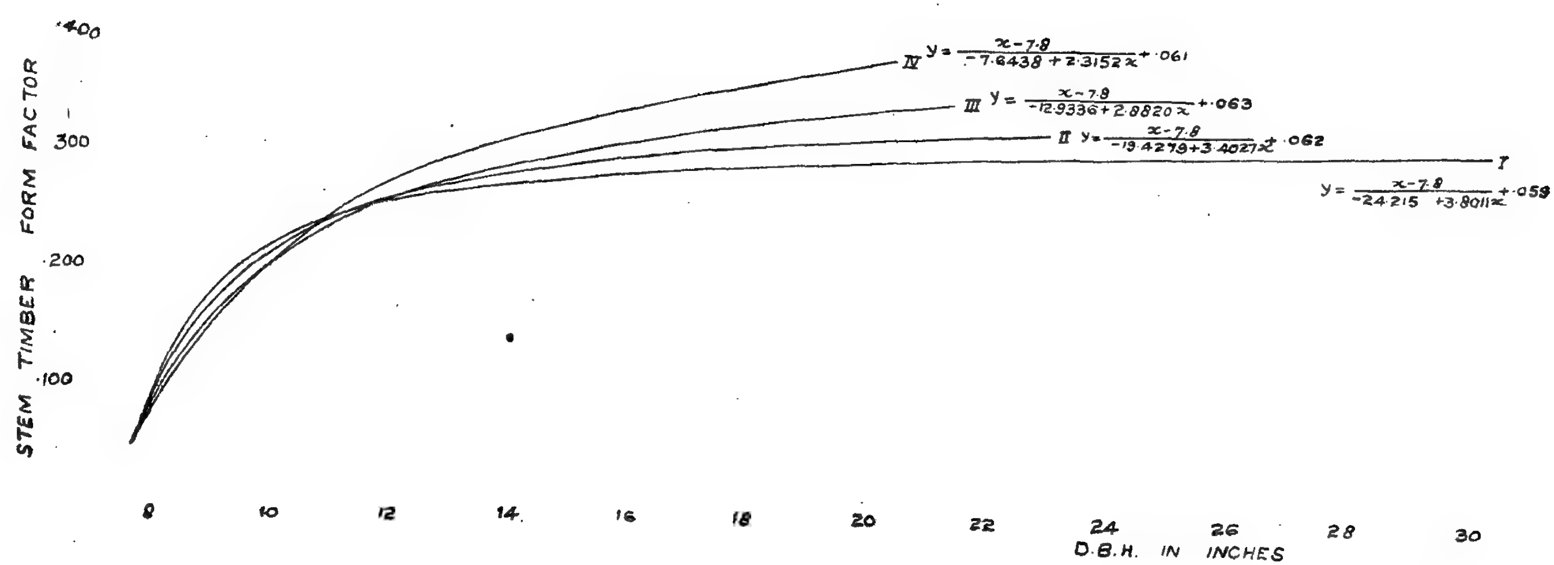
TABLE 1.—*Values of constants and the final equations*

Site quality	Constants				Final equation
	a	b	x_1	y_1	
I	−24·2154	3·8011	7·8	·059	$y = \frac{x - 7{\cdot}8}{-24{\cdot}2154 + 3{\cdot}8011x} + {\cdot}059$
II	−19·4279	3·4027	7·8	·062	$y = \frac{x - 7{\cdot}8}{-19{\cdot}4279 + 3{\cdot}4027x} + {\cdot}062$
III	−12·9336	2·8820	7·8	·063	$y = \frac{x - 7{\cdot}8}{-12{\cdot}9336 + 2{\cdot}8820x} + {\cdot}063$
IV	− 7·6438	2·3152	7·8	·061	$y = \frac{x - 7{\cdot}8}{-7{\cdot}6438 + 2{\cdot}3152x} + {\cdot}061$

TECTONA GRANDIS (PLANTATION)

MATHEMATICAL CURVES

STEM TIMBER FORM FACTOR/ D.B.H.



12-12.52

Accuracy of the mathematical curves—Mathematical curves were drawn from the computed values for different site qualities separately. For testing the accuracy of the curves the data of trees from clear-felled sample plots were used and the volumes obtained by actual measurement were compared with the volumes calculated by applying the form factors obtained from the mathematical curves constructed.

TABLE 2.—*Comparison of the volume figures obtained by the use of the mathematical curves with the actual ones derived after clear-felling*

Forest division and state	S.P. No.	Site quality	Stem timber volume per acre (c.ft.) obtained by		% difference on the basis of the actual figures
			Clear-felling	The use of the proposed equation	
Angul, Orissa ..	10	II	1964	2046	4·2
Palamau, Bihar ..	1	II	1470	1404	— 4·5
Nilambur, Madras	17	II	3371	3678	9·1
Nilambur, Madras	18	II	2351	2465	4·8
Nilambur, Madras	19	III	1782	1847	3·6

The results obtained with the help of the equations are on the whole quite satisfactory. It is only for S.P. No. 17, that the percentage difference is 9·1 ; in the remaining four cases, the difference does not exceed 5%.

Comparison of the results obtained by the use of the mathematical curves with those derived by Schwappach's method—Another step taken to test the efficiency of the equation and the results obtained from it was to compare the volume figures obtained by the standard (Schwappach's) method with those derived from the use of the mathematical curves now set up. For this purpose, sample plots of different ages and various site qualities were taken at random from the existing teak sample plots of different states. For calculation of volume, the various group basal area and heights were taken as entered in S.P. Form No. 5, but the stem timber form factors were then read from the mathematical curves. The differences in volume per cents were calculated on the basis of the figures obtained by Schwappach's method.

A glance at appendix (6), reveals that the variation, in a few cases, is wide. This may give rise to doubt that the new equation set up is not reliable. But, on examination and a careful study of the sample plot files, it was discovered that in the majority of cases this variation was largely due to : (1) mixing of timber volume with smallwood volume and keeping both in one group, and (2) mistakes in the selection of sample trees, which is often influenced by the personal judgment. It is well known that when sample trees are selected by different persons in the same plot the differences in volume are often appreciable. This fact namely that big differences in calculated volume can be caused by faulty selection of sample trees has been shown by me in Table (18) part II of my paper : "Sampling Techniques for estimating Tree Growth and Volume by Selection of Sample Trees for Measurement within

individual Sample Plots", published in the December, 1949 issue of the *Indian Forester*. For some of the plots, actually there existed trees containing timber volume, but none of the sample trees selected contained any timber volume, and so the difference was cent per cent.

Advantage of the formula evolved for teak—The mathematical curves may only be used if and when a sample tree or trees especially of bigger diameters are not available for calculating volume of top group or groups of a crop provided actual measurements have been taken of diameters and standing heights.

Application of the formula—The formula $y = \frac{x - x_1}{a + bx} + y_1$ with its contants calculated for different timber species both broad leaved and coniferous, can similarly be applied to them to determine stem timber form factor as it has been done for *Tectona grandis* in this paper. It is hoped that the equations or the mathematical curves so fitted will give satisfactory results acceptable for all practical purposes.

I have also worked out a suitable equation for determining the stem smallwood volume of a tree. For teak and deodar the general equations are

$$y = 2 \cdot 279e^{-\cdot 2549x} - 2 \cdot 809e^{-\cdot 5060x} \quad \text{and}$$

$$y = 1 \cdot 890e^{-\cdot 2378x} - 2 \cdot 517e^{-\cdot 5769x}$$

respectively. Full details along with mathematical curves will be given in a separate paper.

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APPENDIX I

Basic data for Site Quality I

D.b.h. (ins.)	Average d.b.h. (ins.)	Stem timber form factor	Average stem timber form factor
7·5	7·8	·055	·059
7·6		·056	
7·6		·069	
7·6		·080	
7·7		·034	
7·7		·030	
7·7		·044	
7·8		·096	
7·8		·060	
7·8		·037	
7·9		·064	
7·9		·046	
7·9		·062	
8·0		·051	
8·0		·080	
8·0		·080	
8·0		·076	
8·0		·050	
8·1	8·5	·102	·103
8·2		·077	
8·2		·078	
8·2		·145	
8·2		·116	
8·4		·083	
8·4		·101	
8·5		·109	
8·6		·116	
8·6		·102	
8·6		·107	
8·8		·098	
9·0		·107	
9·0		·107	
9·1	9·6	·153	·173
9·2		·164	
9·2		·199	
9·2		·210	
9·3		·144	
9·3		·146	
9·5		·136	
9·5		·152	
9·5		·181	
9·6		·250	
9·6		·140	
9·6		·148	
9·7		·153	
9·7		·189	
9·7		·155	
9·9		·252	
10·0		·175	
10·0		·176	
10·0		·221	
10·0		·118	

D.b.h. (ins.)	Average d.b.h. (ins.)	Stem timber form factor	Average stem timber form factor
10·4	10·6	·171	·209
10·4		·298	
10·5		·215	
10·6		·212	
10·9		·176	
11·0		·181	
11·1	11·6	·208	·238
11·2		·239	
11·2		·184	
11·2		·291	
11·2		·220	
11·3		·219	
11·5		·247	
11·6		·168	
11·6		·224	
11·6		·259	
11·8		·197	
11·8		·247	
11·8		·254	
12·0		·279	
12·0		·310	
12·0		·262	
12·1	12·5	·258	·256
12·3		·217	
12·4		·276	
12·5		·204	
12·8		·267	
12·8		·313	
13·2	13·6	·270	·270
13·5		·271	
13·6		·279	
13·9		·253	
14·0		·276	
14·8	14·8	·271	·271
15·2	15·4	·275	·307
15·5		·339	
16·1	16·5	·333	·298
16·9		·263	
17·6	17·7	·316	·318
17·7		·350	
17·7		·289	
18·8	18·8	·327	·327

D.b.h. (ins.)	Average d.b.h. (ins.)	Stem timber form factor	Average stem timber form factor
19·1	19·3	·337	·345
19·5		·352	
19·3		·346	
20·4	20·4	·350	·350
21·2	21·2	·324	·324
22·3	22·4	·351	·321
22·5		·291	
23·4	23·4	·314	·314
24·3	24·3	·329	·329
25·4	25·4	·318	·318
25·4		·318	
26·5	26·5	·369	·369
27·6	27·7	·300	·306
27·7		·312	
32·4	32·4	·261	·261
36·4	36·4	·246	·246

APPENDIX 2

CALCULATION FOR SOLVING THE HYPERBOLIC CURVE

$$y = \frac{x - x_1}{a + bx} + y_1$$

Tectona grandis Quality I

D.b.h. in inches (x)	Observed stem timber form factor (y)	(x—7·8)	(y—·059)	$\frac{x-7\cdot8}{y-\cdot059}$ (z)	Computed stem timber form factor (y′)
7·8	·059	0	0	0	·059
8·5	·103	0·7	·044	15·909	·145
9·6	·173	1·8	·114	15·789	·206
10·6	·209	2·8	·150	18·667	·233
11·6	·238	3·8	·179	21·229	·250
12·5	·256	4·7	·197	23·858	·261
13·6	·270	5·8	·211	27·488	·270
14·8	·271	7·0	·212	33·019	·277
15·4	·307	7·6	·248	30·645	·280
16·5	·298	8·7	·239	36·402	·285
17·7	·318	9·9	·259	38·224	·289
18·8	·327	11·0	·268	41·045	·292
19·3	·345	11·5	·286	40·210	·293
20·4	·350	12·6	·291	43·299	·295
21·2	·324	13·4	·265	50·566	·297
22·4	·321	14·6	·262	55·725	·299
23·4	·314	15·6	·255	61·176	·300
24·3	·329	16·5	·270	61·111	·301
25·4	·318	17·6	·259	67·954	·302
26·5	·369	18·7	·310	60·323	·303
27·7	·306	19·9	·247	80·567	·304
32·4	·261	24·6	·202	121·782	·308
36·4	·246	28·6	·187	152·941	·310

$\Sigma x_1 = 149\cdot6$, $\Sigma z_1 = 302\cdot275$, $n_1 = 11$,

$\Sigma x_2 = 279\cdot4$, $\Sigma z_2 = 795\cdot654$, $n_2 = 11$

$302\cdot275 = 11a + 149\cdot6b$ ......(I)

$795\cdot654 = 11a + 279\cdot4b$ ......(II)

$\therefore\ a = -24\cdot2154$,

$b = 3\cdot8011$ and

$$\frac{x-7\cdot8}{y-\cdot059} = -24\cdot2154 + 3\cdot8011x$$

$$\text{or } y = \frac{x-7\cdot8}{-24\cdot2154+3\cdot8011x} + \cdot059$$

APPENDIX 3

CALCULATION FOR SOLVING THE HYPERBOLIC CURVE

$$y = \frac{x - x_1}{a + bx} + y_1$$

Tectona grandis Quality II

D.b.h. in inches (x)	Observed stem timber form factor (y)	(x—7·8)	(y—·062)	$\frac{x-7\cdot8}{y-\cdot062}$ (z)	Computed stem timber form factor (y′)
7·8	·062	0	0	0	·062
8·5	·114	0·7	·052	13·462	·136
9·6	·172	1·8	·110	16·364	·198
10·6	·229	2·8	·167	16·766	·230
11·6	·264	3·8	·202	18·812	·252
12·7	·297	4·9	·235	20·851	·268
14·6	·312	6·8	·250	27·200	·287
15·6	·342	7·8	·280	27·857	·294
16·9	·330	9·1	·268	33·955	·301
17·5	·315	9·7	·253	38·340	·304
18·4	·290	10·6	·228	46·491	·307
19·3	·295	11·5	·233	49·356	·311
20·8	·297	13·0	·235	55·319	·315
21·9	·312	14·1	·250	56·400	·318

$\Sigma x_1 = 67\cdot6$, $\Sigma z_1 = 113\cdot455$, $n_1 = 6$,

$\Sigma x_2 = 130\cdot4$, $\Sigma z_2 = 307\cdot718$, $n_2 = 7$

$113\cdot455 = 6a + 67\cdot6b$ ......(I)

$307\cdot718 = 7a + 130\cdot4b$ ......(II)

$\therefore\ a = 19\cdot4279$,

$b = 3\cdot4027$ and

$$y = \frac{x-7\cdot8}{-19\cdot4279+3\cdot4027x} + \cdot062$$

APPENDIX 4

CALCULATION FOR SOLVING THE HYPERBOLIC CURVE

$$y = \frac{x - x_1}{a + bx} + y_1$$

Tectona grandis — Quality III

B.b.h. in inches (x)	Observed stem timber form factor (y)	(x−7·8)	(y−·063)	$\frac{x-7\cdot8}{y-\cdot063}$ (z)	Computed stem timber form factor (y′)
7·8	·063	0	0	0	·063
8·5	·127	0·7	·064	10·938	·124
9·5	·164	1·7	·101	16·832	·181
10·6	·212	2·8	·149	18·792	·222
11·5	·253	3·7	·190	19·474	·246
12·5	·288	4·7	·225	20·889	·267
13·6	·269	5·8	·206	28·155	·284
14·7	·297	6·9	·234	29·487	·297
15·3	·335	7·5	·272	27·574	·304
16·5	·331	8·7	·268	32·463	·314
17·3	·300	9·5	·237	40·084	·320
18·2	·322	10·4	·259	40·154	·326

$\Sigma x_1 = 52\cdot6$, $\Sigma z_1 = 86\cdot925$, $n_1 = 5$,

$\Sigma x_2 = 95\cdot6$, $\Sigma z_2 = 197\cdot917$, $n_2 = 6$

$86\cdot925 = 5a + 52\cdot6b \ldots\ldots$ (I)

$197\cdot917 = 6a + 95\cdot6b \ldots\ldots$ (II)

$\therefore\ a = -12\cdot9336,$

$b = 2\cdot8820$ and

$$y = \frac{x - 7\cdot8}{-12\cdot9336 + 2\cdot8820x} + \cdot063$$

APPENDIX 5

CALCULATION FOR SOLVING THE HYPERBOLIC CURVE

$$y = \frac{x - x_1}{a + bx} + y_1$$

Tectona grandis — Quality IV

D.b.h. in inches (x)	Observed stem timber form factor (y)	(x−7·8)	(y−·061)	$\frac{x-7\cdot8}{y-\cdot061}$ (z)	Computed stem timber form factor (y′)
7·8	·061	0	0	0	·061
8·5	·119	0·7	·058	12·069	·119
9·6	·187	1·8	·126	14·286	·184
10·6	·226	2·8	·165	16·970	·227
11·5	·254	3·7	·193	19·171	·256
12·5	·280	4·7	·219	21·461	·282
13·5	·319	5·7	·258	22·093	·302
14·4	·328	6·6	·267	24·719	·318
16·8	·329	9·0	·268	33·582	·349

$\Sigma x_1 = 40\cdot2$, $\Sigma z_1 = 62\cdot496$, $n_1 = 4$,

$\Sigma x_2 = 57\cdot2$, $\Sigma z_2 = 101\cdot855$, $n_2 = 4$

$62\cdot496 = 4a + 40\cdot2b \ldots\ldots$ (I)

$101\cdot855 = 4a + 57\cdot2b \ldots\ldots$ (II)

$\therefore\ a = -7\cdot6438,$

$b = 2\cdot3152$ and

$$y = \frac{x - 7\cdot8}{-7\cdot6438 + 2\cdot3152x} + \cdot061$$

APPENDIX 6

COMPARISON OF STEM TIMBER VOLUME FIGURES OBTAINED BY THE USE OF MATHEMATICAL CURVES WITH THOSE OBTAINED BY THE STANDARD METHOD

Sample Plot No.	Forest Division and State	Site Quality	Year of measurement	Stem timber Vol. (c.ft.) obtained by Standard method †	the use of the proposed mathematical curve	%* difference
2	Melghat, M.P.	IV	1924	209·90 (1)	230·76	9·9
		IV	1929	379·47 (4)	394·47	4·0
		IV	1934	538·23 (3)	553·88	2·9
		IV	1944	1089·86 (4)	923·61	−15·3
3	Melghat, M.P.	IV	1924	15·99 (2)	16·22	1·4
		IV	1929	67·36 (3)	60·19	−10·6
		IV	1934	178·02 (1)	154·34	−13·3
		IV	1944	352·83 (4)	410·85	16·4
5	Melghat, M.P.	III	1934	4·08 (1)	3·63	−11·0
		III	1944	42·64 (2)	48·33	13·3
6	Melghat, M.P.	III	1934	5·25 (1)	4·90	− 6·7
		III	1944	64·05 (4)	63·26	− 1·2
7	Melghat, M.P.	IV	1924	278·18 (4)	273·62	− 1·6
		IV	1929	403·81 (5)	405·71	0·5
		IV	1934	499·01 (3)	514·53	3·1
		IV	1944	759·74 (5)	755·55	− 0·6
8	Melghat, M.P.	IV	1924	128·40 (2)	135·19	5·3
		IV	1929	230·20 (3)	265·33	15·3
		IV	1934	276·46 (3)	285·80	3·4
		IV	1944	565·64 (5)	557·92	− 1·4
9	Melghat, M.P.	III	1924	666·49 (4)	697·71	4·7
		III	1929	933·19 (5)	992·81	6·4
		III	1934	1089·74 (5)	1119·68	2·7
11	Melghat, M.P.	IV	1924	24·12 (2)	26·94	11·7
		IV	1929	106·68 (2)	93·95	−11·9
		IV	1934	214·22 (2)	202·71	− 5·4
		IV	1944	498·37 (4)	539·50	8·3
34	Gorakhpur, U.P.	II	1944	20·39 (1)	20·62	1·1
		II	1949	225·47 (4)	241·47	7·1
45	Haldwani, U.P.	I	1946	890·70 (8)	1030·57	15·7
		I	1951	1682·47 (8)	1646·08	− 2·2
46	Haldwani, U.P.	I	1938	32·27 (3)	32·87	1·9
		I	1946	929·61 (8)	1097·78	18·1
		I	1951	1729·02 (8)	1669·53	− 3·4

* Calculated on the basis of the figures obtaided by the standard method. *(contd.)*

† Figures in brackets are the number of sample trees taken each year.

APPENDIX 6—(*concld.*)

COMPARISON OF STEM TIMBER VOLUME FIGURES OBTAINED BY THE USE OF MATHEMATICAL CURVES WITH THOSE OBTAINED BY THE STANDARD METHOD

Sample Plot No.	Forest Division and State	Site Quality	Year of measurement	Stem timber Vol. (c.ft.) obtained by: Standard method	the use of the proposed mathematical curve	%* difference
7	Nilambur, Madras	I	1928	1218·55 (6)†	1199·66	− 1·6
		I	1937	1701·79 (3)	1593·20	− 6·4
		I	1948	2019·67 (5)	2088·23	3·4
8	Nilambur, Madras	I	1928	1602·47 (5)	1454·69	− 9·2
		I	1938	1865·80 (3)	1906·14	2·2
9	Nilambur, Madras	I	1928	3673·75 (4)	3796·26	3·3
		I	1938	5079·98 (3)	4937·56	− 2·8
		I	1950	6183·58 (4)	6409·48	3·7
10	Nilambur, Madras	II	1928	1357·55 (5)	1284·61	− 5·4
		II	1938	1931·71 (3)	1929·04	− 0·1
11	Nilambur, Madras	III	1928	589·04 (5)	542·12	− 8·0
		III	1938	662·09 (3)	732·52	10·6
12	Nilambur, Madras	I	1928	3880·79 (5)	3396·97	−12·5
		I	1938	5779·51 (3)	5006·84	−13·4
		I	1948	5774·26 (7)	5213·65	− 9·7
13	Nilambur, Madras	II	1928	880·18 (3)	965·73	9·7
		II	1938	1559·23 (3)	1394·90	−10·5
		II	1948	1320·42 (7)	1325·25	0·4
14	Nilambur, Madras	III	1928	418·23 (5)	378·65	− 9·5
		III	1938	644·17 (3)	579·54	−10·0
		III	1948	711·58 (8)	722·66	1·6
15	Nilambur, Madras	I	1928	3416·37 (2)	2972·46	−13·0
		I	1938	3835·12 (3)	3755·94	− 2·1
16	Nilambur, Madras	II	1928	1990·23 (5)	1764·85	−11·3
		II	1938	2778·67 (3)	2516·18	− 9·4
49	Nilambur, Madras	I	1928	61·77 (1)	83·31	34·9
		I	1938	327·07 (4)	398·20	21·7
		I	1949	519·64 (6)	556·39	7·1
1	Wynaad, Madras	II	1924	1497·62 (6)	1539·80	2·8
		II	1931	1610·09 (7)	1537·50	− 4·5
		II	1936	2167·83 (4)	2004·82	− 7·5
		II	1942	2273·10 (7)	2119·55	− 6·8
		II	1950	3321·68 (5)	3068·36	− 7·6
10	Angul, Orissa	II	1945	1973·00 (8)	2051·00	4·0
14	West Kanara, Bombay ..	III	1941	3492·25 (5)	3564·11	2·1
15	West Kanara, Bombay ...	IV	1941	1867·78 (6)	1976·93	5·8

* Calculated on the basis of the figures obtained by the standard method.

† Figures in brackets are the number of sample trees taken each year.

RESULTS OF AN EXPERIMENT TO STUDY THE SUCCESSION OF GROUND FLORA SPECIES UNDER FOREST PLANTATIONS RAISED ON OLD AGRICULTURAL LAND IN THE NEW FOREST, DEHRA DUN, INDIA

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INTRODUCTION

The study of the development and succession of ground flora communities in a forest is of practical importance to forestry. The ground flora community not only indicates the fertility status of the forests, but gives also an idea of the growth and development of tree seedlings as it is intimately related to it. In India, it is considered that some species of grasses and other under-growth adversely affect the growth of sal seedlings. Similar views are held about the regeneration of some other forest species as well. The indicator value of ground flora communities has been utilized in defining forest types (Cajander, 1926, 1949) and management types (see Heimburger, 1933).

Ground flora species have been used by Mohan (1933) and Suri (1933) in determining the management types of some conifer forests of the Kangra and Kulu valleys. Hole (1911) and Osmaston (1922) have also made some observations on the use of ground flora species as plant indicators.

The nature of the ground flora species including tree seedling-growth and its development in a forest is dependent to a certain extent upon the tree cover. But the exact manner in which tree cover influences the growth and development of growth flora in Indian forests and plantations is not clearly known, however.

To fill up this gap in our knowledge of the Silviculture of Indian forest trees the Silviculturist, Forest Research Institute, marked some ground flora quadrats in 1926 in tree plantations then formed in the New Forest and kept them under observation till 1948. The data collected over the 22-year period has now been examined to see the nature, spread and development of the various ground flora species, under the different plantation covers.

The New Forest Estate, which houses the Forest Research Institute is located on old agricultural land. The Institute is about 1,100 acres in extent. On the eastern corner of the Estate some land had been set aside for raising experimental forest plantations of a number of species. The forest trees tried in 1925 are *Dalbergia latifolia*, *Gmelina arborea*, *Tectona grandis*, *Shorea robusta* and *Pinus longifolia*. In each of these plantations, one quadrat of 14 × 14 feet or 15 × 15 feet was laid out in 1926–28 for periodic study of ground flora species.

In a few quadrats, the locations of some important ground flora species were marked on graph papers and the extent of their spread was charted in relation to the spread of the tree canopy. The abundance of each species was recorded by counting the number of individuals of that species in the quadrat at least once every year. These figures have been used to determine frequency of each species. The frequency of the species is the percentage of its number to the total number of individuals of all the species in a quadrat.

In some years, however, only visual estimations of the frequency of ground flora species were made, during the months of May, July, August, September, October and November and records were made as abundant, frequent, rare, etc. The field data are given in the following paragraphs.

THE GROUND FLORA QUADRATS

The observations were made on ground flora quadrats in the various plantations, during the periods given in Table 1.

TABLE 1

Serial No.	Tree species in the plantation	Comptt. No.	Years of laying out of the quadrats	Years when frequency of ground flora was recorded	Reasons for closing the quadrats
1	*Dalbergia latifolia* ..	9	1928	1932, 33, 34 and 35	Area leased for taungya cultivation.
2	*Dalbergia latifolia* ..	11	1931	1932, 33, 34 and 35	Area leased for taungya cultivation.
3	*Gmelina arborea* ..	10	1928	1932, 33, 34 and 35	Experiment concluded, reason not recorded.
4	*Tectona grandis* ..	15	1928	1930, 32, 33, 34, 35, 36, 37 and 38	Area given for cultivation.
5	*Tectona grandis* ..	38	1931	1932, 33, 34 and 35	Area leased for taungya cultivation.
6	*Shorea robusta* ..	20	1928	1930, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47 and 48.	
7	*Shorea robusta* ..	18	1931	1932, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47 and 48	
8	*Pinus longifolia* ..	41	,,	1932, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47 and 48	
9	*Pinus longifolia* ..	23 (unburnt)	,,	1931, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47 and 48	
10	*Pinus longifolia* ..	23 (unburnt)	,,	1936, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47 and 48	

In some quadrats in which the frequency of ground flora species was recorded in May, July and September, an interesting periodicity of ground flora species is seen. For example, some species which were absent in May, became frequent and abundant in July and September. There were others which were very abundant in May, but later on their percentage declined in July to September and some of these even disappeared in this period.

The differences in growth were well marked in some species during the three periods of observation.

The seasonal periodicity in ground flora vegetation in Indian forests is well known. This is due most probably to seasonal changes in climate and soil. Phenological changes in tree cover may also be responsible for seasonal differences in the occurrence of ground

flora species. With a view to understanding the phenomenon of seasonal periodicity in the ground flora vegetation it would be desirable to examine the climate and soil conditions of the New Forest Estate.

CLIMATIC CONDITIONS OF THE NEW FOREST

The climate of the New Forest is typically monsoonal with the maximum amount of rain falling during the months of July to September (see Table 2). Depending upon the start and spread of monsoons a good amount of rainfall may occur in the month of June in some years. In the months of January and February, some rain usually falls from retreating monsoons. Even in the driest months of April and May some showers, probably arising from local conditions, do occur. These tend to keep down temperatures and increase the relative humidity of the air and the soil. On account of its situation in a valley, with the Himalayas in the North and the Siwaliks in the South, the Estate does not experience extremes of climate. In normal years, maximum temperatures may not go far above 105°F. and minimum may not go below 38°F. to 40°F. for many days.

The mean daily temperature from 1929–45 is 81°F. during May–June. Relative humidity remains quite high throughout the year. Hot *loo* and dust storms are rare, though during the months of April and May strong winds usually blow. The relative humidity during these months is usually low. Although, the climate of New Forest Estate does not fluctuate much from year to year, years of drought and severe frost have sometimes been recorded.

TABLE 2

Average monthly values of rainfall, mean temperature and humidity per cent at New Forest during the period 1929–45

Months	Rainfall in inches	Mean temperature in degrees Fahrenheit	Humidity %*
January ..	2·7	51	79
February ..	2·3	55	76
March ..	1·3	64	62
April ..	0·9	73	48
May ..	1·7	81	43
June ..	8·1	81	61
July ..	26·1	78	85
August ..	26·8	77	89
September ..	11·3	75	82
October ..	1·3	69	68
November ..	0·1	61	66
December ..	1·2	54	75
Mean annual rainfall = 83·8 inches.			

* Most of the readings were taken at 8 a.m. while a few were taken at 10 a.m.

Frost is a specially marked feature during the months of January and February, when ground flora species and tree seedlings at ground level suffer. Occasionally hail and snowfall occur at the New Forest ; the last snowfall was in 1945. During the months of January and February when snowfalls on the Himalayan mountains, temperatures go down considerably and cold wind sweeps the valley.

Some species of the ground flora vegetation are at their best during the rains, while others show the best growth during spring. During the months of April and May when the weather is extremely dry, some of the ground flora species shrivel and die or lie dormant in the ground in seeds, tubers, bulbs, etc. Their sprouting takes place with the first shower of rains.

SOIL CONDITIONS

The soils of the New Forest plantations are clayey down to about 6 to 7 feet. Below 7 feet, there is a layer of conglomerate in which, sometimes, loose pebbles and stones of various sizes are found. Since the area slopes gently from N–E (chir pine plantations) to S–W (teak plantations), the depth of the clay is somewhat low in the N–E corner and increases towards the lower part of the slope, under the teak. Geologically, the soils form part of the Dun clays and gravels which are residual in nature. On account of the area having been under field crops for many years, prior to the afforestation, the original nature of the clays is greatly disturbed. These are non-calcareous and ferruginous, with a pH value ranging between 5 and 6·5. The underlying strata of the conglomerate, which are nowhere seen on the surface in the area, and are unimportant for this study, are, however, calcareous at some places.

There are interesting seasonal variations in the moisture content, organic matter, pH value and exchangeable calcium in the soils of the various plantations in the New Forest. These have been recently studied by Puri and Prem Nath (1952). During the dry season, the surface soils are dry and their pH and exchangeable Ca contents are higher. During rains due to leaching, the surface soils become more acidic and have lesser amounts of exchangeable Ca. These features would probably have a pronounced effect on the growth and development of ground flora species but sufficient work has not been done to establish any relationship. During the monsoon there is a pronounced leaching, but during the remaining part of the year there is either evaporation or no leaching.

The resultant effect of the climate is that exchangeable Ca and pH of the surface layers in *these* areas tend to remain high. Depending upon the nature of the tree litter, its chemical composition, etc., there will be small differences in seasonal variations of the various constituents of the soil. For example, in the Chir pine and sal plantations which are non-exacting species, the level of the soil Ca and pH is generally somewhat lower than in the teak.

The changes in the soil conditions due to afforestation have been studied for a number of years, and these tend to show that, there is an overall increase in the contents of organic matter and moisture in the various plantations with the progress of the growth of tree vegetation. Nitrogen has also increased in the surface layers of the soil. There are, however, interesting differences in humus content in the various plantations probably due to the chemical composition of the litter and the state of its decomposition. The studies on any detailed relationship between soil changes and ground flora species have, however, not been done so far.

Phenological data for a number of years for 17 forest trees planted in the Estate was recently analysed. These show that leaf bud-opening and leaf fall in the various tree species

occurs in different months. Phenological behaviour of tree species may have a bearing on the nature of the ground flora and their spread by altering light, moisture and temperature conditions which might influence the growth of ground vegetation under plantations. There is, however, no precise data on this at present.

The foliar content of the various tree species also varies with seasons. On the whole, it was seen that in deciduous species which become leafless from the month of November to February and March there is a gradual increase in the Ca content of leaves from the leaf bud-opening to leaf fall stage. For the same period there is a decrease in the exchangeable calcium of the soil. There is also a general decrease in the N content of the deciduous species from leaf bud-opening to leaf fall. In conifer and semi-deciduous and evergreen species there is likewise a similar seasonal change, though, it is gradual and not rapid (Puri and Gupta 1952). The seasonal fluctuation in the foliar constituents of forest tree species are intimately related to amounts of these substances present in the soil, and thus would probably affect the growth of ground flora species from season to season. The foliar constituents of ground flora species have not so far been determined. The relationship between these, therefore, cannot be established at present.

The above features of climate, soil conditions and tree phenology seem to show that from the point of view of plant growth, the year in the New Forest may be divided into four well defined growth seasons :—

(1) Dry season of which the month of May may be representative. In this period soil moisture is at its lowest. New flush of leaves in deciduous trees appears, so light conditions in the forest floor get somewhat diminished.

(2) Monsoon period of which July–August may be representative. In this period the soil is flooded with water ; pH and exchangeable Ca of the surface layers of the soil are low. Trees are in full foliage and as the sky remains cloudy for most of the time evaporation from the soil is small and leaching would probably predominate.

(3) Post-monsoon period of which September to October may be representative. During this period soil starts drying and the process of leaching changes to evaporation, increasing the soil exchangeable Ca and pH. Although, forest trees are in full leaf light intensity is comparatively more due to clear skies.

(4) In the cold period of which January to February may be typical months, there is again a slight leaching in the soil due to rainfall. The soil exchangeable Ca and pH, however, do not fall appreciably. In quite a number of tree species, leaf fall starts at this time of the year, so light and temperature conditions in the forest floor may change considerably.

DALBERGIA LATIFOLIA PLANTATIONS

Two quadrats were laid out, one in comptt. 9 in the year 1928 and the other in comptt. 11 in 1931. The observations in both the quadrats were concluded in 1936, as due to fungus and frost attacks, plants had died and the canopy had become too open to exercise any probable effect on the ground flora vegetation.

In comptt. 9, Rosewood plantation was raised in 1928 by sowing at an espacement of 6 feet and one quadrat of 14 × 14 feet was laid out in May 1928. In May 1934, plants were attacked by a fungus and trees had become leafless. In September 1934, the tree canopy had become greatly reduced and by 1935 it became still further so. In September 1935, the plot had become more or less open with a few dying plants of rosewood, which had by that time attained a height of 3 to 10 feet only.

The ground flora vegetation in this quadrat was formed of *Ageratum conyzoides* – *Andropogon muricatus* community. As will be seen from Table 3, there are a number of associated species in the community, with low frequency, of which two, namely *Euphorbia hirta* and *Rottboellia compressa* had a frequency of more than 10%, in the beginning. With the development of trees this community maintained itself and in September 1934, *Andropogon muricatus* increased in frequency by about 1½ times of what it was in the beginning. *Ageratum conyzoides* did not show any decline in its frequency which may probably be due to the death of the trees, or to some other favourable factor.

TABLE 3

Frequency as percentage of the total number of species in a quadrat of Dalbergia latifolia laid out in comptt. 9 in 1928

Serial No.	Condition of trees / Species	29–9–1932	22–9–1933	May 1934 trees attacked by fungus and became leafless / 30–9–1934	23–9–1935
1	*Ageratum conyzoides*	40·0	42·7	43·4	37·8
2	*Andropogon muricatus*	17·0	9·7	26·4	Data not clear
3	*Artemisia vulgaris*	..	4·8	3·8	13·4
4	*Bothriochloa pertusa*	8·5	22·6	7·6	Data not clear
5	*Bidens pilosa*	1·7	0·8	..	..
6	*Cryptolepis buchanani*	..	..	..	0·8
7	*Cynodon dactylon*	0·8	..	..	19·7
8	*Desmodium polycarpum*	..	..	..	0·8
9	*Dichanthium annulatum*	2·6	6·4	5·6	..
10	*Epuhorbia hirta*	12·0	2·5	..	..
11	*Paspalum scrobiculatum*	1·7	..	..	..
12	*Rottboellia compressa*	12·0	9·7	13·2	16·5
13	*Setaria glauca*	..	..	..	0·8
14	*Sorghum halepense*	2·6	..	..	..
15	*Triumfetta annua*	..	0·8	..	..
16	*Triumfetta rhomboidea*	..	..	..	7·1
17	*Urena lobata*	0·8	..	..	3·1
	Total number of species during various years of observations	11	9	6	11

In comptt. 11 rosewood was raised in 1928 by planting stumps at 6 × 6 feet interval and one ground flora quadrat of 15 × 15 feet was laid out, in 1931. Rosewood plants were infected by a fungus in this plantation as well, and by May 1934 some plants had died. At the time of the abandoning the experiment the rosewood plants had attained a height of 5–6 feet.

From the ground flora vegetation records given in Table 4, it will be seen that the nature of the *Ageratum* community in this plot is somewhat different from that in comptt. No. 9. Unlike comptt. 9, *Andropogon muricatus* was absent in comptt. 11. *Sorghum halepense* was more prominent in this comptt. than in the first. The ground flora community in this comptt. was *Ageratum conyzoides* – *Imperata cylindrica*. This latter species was not present in compartment 9.

TABLE 4

Frequency of different species as percentage of the total number of species in a quadrat of Dalbergia latifolia laid in compartment 11

Serial No.	Species	22–9–1932	22–9–1933	30–9–1934	23–9–1935
1	*Ageratum conyzoides* ..	43·8	47·7	12·8	10·5
2	*Ajuga bracteosa*	..	..	..	0·6
3	*Andropogon muricatus* ..	..	..	..	0·6
4	*Artemisia vulgaris*	1·8	1·9	..	8·0
5	*Bidens pilosa*	2·7	..	..	..
6	*Bothriochloa pertusa* ..	6·3	2·8	..	3·1
7	*Cassia absus* seedling ..	..	..	..	4·9
8	*Cissampelos pareira* ..	..	..	..	1·8
9	*Dalbergia sissoo* seedling ..	..	1·9	2·9	3·1
10	*Imperata cylindrica* ..	33·0	35·5	84·3	39·0
11	*Melia azaderach* seedling ..	..	..	..	0·6
12	*Phyllanthus urenaria* ..	..	..	..	0·6
13	*Rottboellia compressa* ..	..	..	..	0·6
14	*Saccharum spontaneum* ..	..	..	..	0·6
15	*Sorghum halepense* ..	7·1	9·3	..	1·2
16	*Tridex procumbens* ..	3·5	..	..	..
17	*Urena lobata*	1·8	0·9	..	24·7

From the nature of the ground flora communities it would appear that the ecological conditions in the two quadrats in the *Dalbergia* plantations studied were probably very much different even from the beginning.

Unlike compartment No. 9, the frequency of *Ageratum conyzoides* in comptt. 11 showed a considerable decrease after 1933, even though the Rosewood plants had become leafless by fungus attack, as in the other compartment. The very noticeable feature in comptt. 11 is the appearance in abundance of *Imperata cylindrica*. By 1934, *Imperata* had become very abundant with 84% frequency.

The low frequency of *Ageratum* at this time may be probably due to cutting off of light intensity by *Imperata*, or some other feature.

In 1935, *Imperata* had become about 3 feet high, but its frequency had declined and another species (*Urena lobata*) had become predominant with a frequency of about 24%. Plants of *Urena* were 4 feet high as against 3 feet of *Imperata*.

In this quadrat, there appeared in 1933, three vigorous seedlings of *Dalbergia sissoo*, which by 1935, had attained heights of 8, 15 and 20 feet respectively. Thus, inspite of the

death of the Rosewood plants the overhead was close enough. The decrease in the frequency of *Ageratum* and the differences in the ground flora community may also be partly due to this feature.

The ground flora species exhibit a good deal of periodicity, as will be seen from tables 5 and 6. *Ageratum conyzoides* seems to be at its best in May or slightly before, but its frequency declines afterwards. A number of species such as *Cassia tora*, *C. absus*, *Rottboellia*, *Justicia*, *Phyllanthus*, *Desmodium*, etc., become prominent only after the rains. A similar periodicity is seen in other years as well.

TABLE 5

The periodicity in frequencies of given species of ground flora in a quadrat in Rosewood comptt. 9, laid in 1928 and recorded in 1935

Species	Frequencies (visual estimation only)			REMARKS
	29–9–35	19–7–35	23–9–35	
Ageratum conyzoides ..	Va	a	a	
Andropogon muricatus ..	Va	Va	Va	
Bothriochloa pertusa ..	a	a	a	
Artemisia vulgaris ..	f	f	a	Up to 8 or 10 feet high
Cryptolepis buchanani seedlings	1	1	1	
Cynodon dactylon ..	f	f	f	
Desmodium triflorum ..	2	0	..	
Jasminum pubescens seedlings ..	1	1	..	
Urena lobata ..	2	4	4	
Zizyphus jujuba seedlings ..	1	1	..	
Cassia tora ..	..	1	1	
Dioscorea sp. ..	..	f	1	
Rottboellia compressa ..	..	f	f	
Tridax procumbens ..	..	1	..	
Triumfetta rhomboidea ..	..	1	f	
Justicia simplex ..	..	..	4	
Phyllanthus urinaria ..	..	..	3	
Desmodium polycarpum ..	..	..	2	
Cassia absus ..	..	..	3	
Setaria glauca ..	..	..	r	
Euphorbia hirta ..	..	..	1	
Oxalis corniculata ..	..	..	1	
Physalis minima ..	..	..	1	

Va = Very abundant. a = abundant.

f = frequent. r = rare.

0, 1, 2, 3, etc., give actual numbers of plants of species.

TABLE 6

The periodicity in frequencies of given species of ground flora in a quadrat in Rosewood comptt. 11 laid in 1931, and recorded in 1935

Species	Number of frequency (visual estimation)			REMARKS
	29–5–35	19–7–35	23–9–35	
Ageratum conyzoides ..	a	r	f	
Dichanthium annulatum ..	Vr	..	..	
Artemisia vulgaris ..	f	f	f	
Cynodon dactylon ..	Vr	Vr	Vr	
Dalbergia sissoo seedlings ..	7	7	7	
Imperata cylindrica ..	Va	Va	Va	
Rottboellia compressa ..	Br	r	r	
Urena lobata ..	f	f	a	
Saccharum spontaneum ..	1	1	1	
Sorghum halepense ..	Vr	2	2(1)	
Cissampelos pariera ..	..	2	4	
Ajuga bracteosa ..	..	3	1	
Melothria sp. ..	..	1	1	
Cassia absus ..	r	f	f	
Bothriochloa pertusa ..	f	f	f	
Andropogon muricatus ..	1(1)	1(1)	1(1)	
Phyllanthus urinaria ..	..	..	4	
Barleria sp. ..	..	1	4	
Physalis minima ..	..	..	1	
Melia azedarach seedlings ..	..	..	1	
Paspalum scrobiculatum ..	..	..	r	

The data, which are unfortunately, not complete, seem to show, however, that there is a seasonal succession in various ground flora species. Seasonal succession might be due to a good many micro-edaphic and micro-climatic factors.

In addition to the seasonal succession, the ground flora species show a pronounced annual succession in the plantations studied.

A closer study of these is indicated as a programme of future research.

[*To be continued*].

MESUA FERREA, LINN., ITS SILVICULTURE AND MANAGEMENT

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[Syn. *M. pedunculata*, Wight (Ironwood of Assam), and *M. speciosa*, Chorsy].

Trade and local names—Mesua. Assamese—*Nohar* ; Bengali—*Nagkesar* ; Uria—*Nageshvaro* ; Marati—*Nagachampa* ; Kanarese—*Nagasampige* ; Malayalam—*Vainavu* ; Telugu—*Nagakesara* ; Coorg—*Atha, Rimpumara* ; Tamil—*Nangal, Suruli* ; Burmese—*Gangaw*.

Description—A large handsome, evergreen tree, often buttressed at the base, with a dense, conical crown of glossy leaves whose under surface is glaucous with a waxy bloom. The young shoots are at first brilliant red (or sometimes yellowish white), then pink or olive and finally dark green. Bark is fairly thin, reddish brown, red within and exfoliates in flat, thin flakes.

Twigs slender, sub 4-angled, *leaves* 2 to 6 inches by $1\frac{1}{2}$ to $1\frac{3}{4}$ inches, base acure or rounded, dark green and shining above, covered more or less with a fine, waxy meal beneath ; veins very fine, close-set, petioles $\frac{1}{4}$ to $\frac{1}{3}$ inch : *Flowers* 3 to 4 inches in diameter, usually terminal and solitary or in pairs, nearly sessile, sweet scented : *Sepals* 4, in 2 rows, orbicular, thick with membranous margins, *Petals* 4, imbricate, *Stamens* many, *Ovary* 2-celled, with 2 ovules in each cell, style filiform, stigma peltate : *Fruit* ovoid, pointed, 1–$1\frac{1}{2}$ inches long, two valved, valves tough, supported by the enlarged sepals, seeds 1–4, testa hard, shining.

The Assam fruit has, in comparison with the South Indian (Malabar) variety, a glossy and less wrinkled surface (*Trop. Agrc.*, Dec. 1933, p. 390).

Distribution—From the Monas River eastward and in Assam especially in Nambar and Charduar, forests, Khasi Hills and in the Jaipur reserve, in the hills of Orissa in permanently moist valleys, in the Andamans especially in the higher hills of the Middle Island, in the forests of the Western Ghats of Deccan from North Kanara southwards through Mysore, Coorg, Malabar (Wynaad Ghats), Nilgiris, Anamalais, Palni hills and Travancore-Cochin. The tree is often cultivated, for its beauty and for the showy flowers it bears, especially round the Buddhist monastries of Assam and Burma. In the Duars the tree is very local, a patch occurring in the Upper Tondu forest of Jalpaiguri forest division and another in Tista Division. In North Bengal it is found chiefly between Neora and Jaldhaka Rivers (C. K. Homfray). In Assam it is one of the principal timber trees and is found in abundance throughout the State in all evergreen forests. In East Bengal (Pakistan) it is found in the Chittagong Hill Tracts, mainly in Kasalong range and sporadically in Chittagong District on cool and shady aspects. In Burma it is found chiefly in Tenasserim. The tree is also found in Ceylon.

Forest types and associate tree species—Mesua ferrea is endemic in the following forest types as classified by H. G. Champion :—

Group 1*a*. *Southern tropical wet evergreen forest.*
- (i) Evergreen *Dipterocarp* forest (1aC1).
- (ii) Western Tropical Evergreen forest (1aC3).
- (iii) Southern Low Tropical Evergreen forest (1aC4).

Group 1*b*. *Northern tropical wet evergreen forest.*
- (i) North Burma Tropical Evergreen forest (1bC1).
- (ii) Upper Assam Tropical Evergreen forest (1bC2).

(iii) Cachar Tropical Evergreen forest (1bC3).
(iv) Chittagong Tropical Evergreen forest (1bC4).
(v) North Bengal Tropical Evergreen forest (1bC5).

Group 2*b*. *Northern tropical semi-evergreen forest.*

(i) Upper Assam Tropical Semi-evergreen forest (2bC1).
(ii) Orissa Tropical Semi-evergreen forest (2bC5).

Moist Tropical Seral Type—Northern (Assam) Tropical Secondary Semi-evergreen forest. (2S/2b).

Western Tropical Evergreen :—found all along the Western Ghats.

Typical localities—(1) *North Kanara*, Bombay—Trees : *Dipterocarpus indicus, Holigarna* sp., *Eugenia gardneri, Mesua ferrea, Nephelium longana, Calophyllum elatum, Diospyros microphylla* (Linear Increment Plot No. 2, E.D. Kanara).

(2) *Agumbe, North Mysore* ; *Ghat Crest Zone—Poeciloneuron – Messua* association with *Lansium anamalayanum* in the underwood. *Poeciloneuron indicum, Mesua ferrea, Dipterocarpus indicus, Hopea parviflora, Calophyllum elatum* and others (Evergreen Linear Tree Increment plot, Agumbe).

(3) *Hassan Ghats, South-West Mysore—Palaquium – Dipterocarpus* association with *Palaquium ellipticum, Mesua ferrea, Kingiodendron pinnatum, Hopea wightiana* and others (K. Kadambi ; *Ind. For.*, Feb. 1950, p. 7).

(4) *Makut in Coorg—Vateria indica, Kingiodendron pinnatum, Dipterocarpus indicus, Cedrela* sp., *Mesua ferrea, Holigarna arnottiana* and others. (Champion, p. 35 ; Van Haeften's Working Plan, p. 7).

(5) *Chandanatode, Wynaad, Madras—Dichopsis, Vateria, Calophyllum tomentosum, Cullenia, Dysoxylum malabaricum, Cedrela toona, Machilus macrantha, Artocarpus hirsuta, Mesua ferrea* and others. (H. G. Champion).

(6) *Wynaad Ghats, Wynaad Division, Shola Type*—The shola of the higher elevations is characterized by the presence of *Mesua ferrea, Dichopsis elliptica* and *Cullenia excelsa.* (A. N. Sarma's Working Plan, p. 6).

(7) *Anamalais, Tunacadavu and Ulandadi blocks*—(*a*) *Hopea – Mesua* association with *Hopea parviflora* and *Mesua ferrea* in dry sholas and (*b*) Upper portion of Kalar valley having *Mesua – Palaquium* association, with *Mesua ferrea* and *Palaquium ellipticum.* (T. V. V. Ayyar's Working Plan, p. 7).

(8) *Shencottah Division, Travancore-Cochin—Hopea parviflora, Cullenia excelsa, Dipterocarpus indicus, Dichopsis elliptica, Machilus macrantha, Mesua ferrea, Calophyllum tomentosum* and others. (M. N. Menon's Working Plan, p. 11).

Southern Low Tropical Evergreen—Andamans, on the upper slopes and tops of hills. Locally called "High Level Evergreen forest". *Dipterocarpus costatus, Mesua ferrea* and *Canarium manii.* (H. S. Deans' Working Plan, p. 11).

Northern Tropical Semi-evergreen—(i) *Hollong-Nahor* type of Lakhimpur and Sibsagar Divisions, Assam, with *Dipterocarpus macrocarpus* (50%) in the upper storey, *Mesua ferrea* (22%) in the understorey. Other important trees include *Artocarpus chaplasha, Amoora wallichii, Terminalia belerica, Eugenia praecox*, etc. (C. G. M. Macarness' Working Plan).

(ii) *Well stocked Nahor type* of the South bank of Brahmaputra River, Lakhimpur Division, Assam with *Mesua ferrea* (35·5%), *Altingia excelsa*, *Dillenia indica* and *Bischofia javanica*. (C. Purakayastha's Working Plan).

Cachar Tropical Semi-evergreen forest, Cachar Division, Assam—*Mixed-evergreen type* (Mohan Lal) confined generally to the northern and eastern aspects of lower slopes, with the trees *Eugenia* spp., *Vatica lanceaefolia*, *Cynometra polyandra*, *Palaquium poyanthum*, *Nephelium longana*, *Canarium resiniferum*, *Mesua ferrea* and several others. (Mohan Lal's Working Plan, p. 3).

Orissa Tropical Semi-evergreen forest—Found on Orissa hills at 2,500 feet or so and in lower, permanently moist valleys. *Mesua ferrea* is found in the second storey of the forest whose top storey contains *Artocarpus lakoocha*, *Michelia champaca*, *Celtis tetrandra*, *Bridelia tomentosa* and others. (Champion, pp. 64–65).

Northern (Assam) Tropical Secondary Semi-evergreen forest—Hollongapar reserve forest of Sibsagar Division, with *Tetrameles nudiflora*, *Stereospermum chelonoides*, *Terminalia myriocarpa* and others in the upper storey and *Macaranga* spp., *Melia azedarach*, *Olea dioica*, *Mesua ferrea* and others in the second storey. (Champion, p. 18).

In the forests of Assam the proportion of *Mesua* to other trees varies greatly, from almost pure crops of *Mesua* to those where the tree is scarce. Pure crops are, however, found over limited areas. In the Charduar reserve of Darrang Division, from Diputa River on the west to Mansiri River on the east, over a distance of 2 to 3 miles there is an almost pure patch. This patch, after a break, continues again from the Aka hills for 2–3 miles almost to the riverain forests fringing the Bhorali (M. A. Jacob). In Nanduar reserve between Rajgharh Ali and Bordikrai Rivers on either bank of the Koilajuli, about one square mile, there is an excellent *Mesua* forest. *Mesua* also occurs as an undercrop or as a prominent member of the crop in Charduar, Bohali and Gohpur reserves. In the Parsighat protected block C, Sadiya Division, *Mesua* forms dense patches along with *Altingia excelsa*, while in Deopani reserved forest of the same division *Mesua* becomes dominant with *Dipterocarpus macrocarpus*. (Purkayastha's Sadiya Working Plan, p. 18).

In Lakhimpur Division of Assam south of Brahmaputra River, *Mesua* forms from 22 per cent of the crop in the *Hollong-Nahor* type to 35 per cent in the *Nahor* type, on high well drained alluvium. (Purakayastha's Working Plan, p. 35).

Rock, Soil and Climate—In the Western Ghat region, where *Mesua* grows the underlying rock is mostly gneiss, coarse grained and quartzose. From the fringe of the Deccan plateaux right down to the sea coast there is often a bed of laterite rock which varies in thickness up to 40 feet. Over some portion of the tract but mostly on hill slopes or at high levels the soil is primary, resulting from the decomposition of the gneiss below, and is a ferruginous sandy loam. It is, on the whole, well drained and porous. In Assam the underlying rock consists of sandstones with grey shales or other sedimentary rocks or occasionally, of outcrops of Archaen red earth as in the Charduar Reserve of Darrang Division where the tree is often pure over considerable areas. The soil is composed of "recent alluvium", a name which covers a very large variety of soils from coarse stony deposits to silts of fine texture (M. C. Jacob). *Mesua* prefers the latter. In Sibsagar District the tree is found on deep, rich loam on flat alluvial ground at elevations of about 200 feet and on undulating ground where the sub-soil is ferruginous gravel or sandstone. In the Jokai Reserve, Lakhimpur, it is found on fertile sandy alluvium above the level of the river floods at elevations of about 450 feet. In the Garo hills it forms a belt along the slopes of the central range at elevations of 1,000 to 3,000 feet in sheltered localities on deep loam resulting from the weathering of metamorphic rocks.

Mesua ferrea is a tropical to semi-tropical tree occurring mostly at elevations from about 200 to 3,000 feet (4,000 feet ; R. S. Browne) in the hills. In its natural habitat the climate is moist, warm and equable, the rainfall varying from about 80 to 325 inches (Agumbe), the absolute maximum shade temperature from 95° to 103°F. and the absolute minimum from 40° to 60°F.

Leaf shedding, flowering and fruiting—Old leaves generally fall during the cold season and the new flush of leaves appears towards the end of that season, usually about the end of February in Assam. In the Western Ghat forests the beginning of the dry season in January is foreboded by a general shedding of the older leaves which continues throughout the dry season. Fresh leafing starts in December (or the latter half of November : Griffith) and continues till the end of February. In the hill sholas this may be from February to early May depending upon weather (Griffith). The large, scented flowers generally appear from February to April ; or from January to April in Travancore (Bourdillon), in April and May in parts of Wynaad (A. N. Sarma), and in Assam also up to end of May or even in June (Troup). The time at which the fruit ripens varies greatly ; in Bengal seeds are ripe from the middle of July to the beginning of September (Homfray), in Assam the time is August–September (R. N. De) or August to October (Troup) ; in North Kanara it is May (Talbot) ; in Mysore June to July (Kadambi) ; in Wynaad Ghats December (A. N. Sarma) or January (Marsden) and in Travancore October to March (Bourdillon).

Seed, germination and the seedling—The oily seeds are 0·8 to 1·1 inch long, oviod or irregularly hemispherical, pointed, with angular sides, smooth, reddish brown. Testa is hard and somewhat brittle. The tree begins to produce fertile seed at 15 to 20 years of age. Isolated trees flower and seed abundantly almost every year, while in the forest good seed years occur at frequent intervals.

Germination—Hypogeous the radicle emerges from the blunt end of the seed and curves downwards. At the same time the petioles of the cotyledons rapidly elongate carrying the plumule with them. The fleshy cotyledons remain underground within the testa and supply the seedling with nourishment for several months.

Roots : primary root long, moderately thick, woody, flexuose, lateral roots numerous, fibrous, distributed down the main root. *Hypocotyl* distinct from root, 2·8–3·5 in. long, thick, terete, tapering upwards, green, glabrous. *Cotyledons* petiolate : petiole 0·25–0·3 in. long, channelled above, minutely pubescent : lamina 2–2·5 in. by 1·5–2·3 in. cordate or ovate, acute, entire, glabrous or minutely pubescent, palmately 5–veined. *Stem* erect, minutely pubescent ; early internodes 0·8–1·5 in. *Leaves* alternate, simple, petiolate. *Stipules* 0·1 in. long, triangular acuminate, pubescent. *Petiole* 0·2–0·3 in. long, channelled above, pubescent. *Lamina* 3–4 in. by 1–1·5 in., elliptical lanceolate, acute, base tapering, sharply serrate, glabrous or with minute hairs on main veins on under-surface ; venation arcuate, lateral veins 6–8 pairs in earlier leaves (Troup, I, 25).

SILVICULTURAL CHARACTERS

Mesua ferrea is a pronounced shade bearer, at all events in its infancy ; once established, its seedlings and saplings cannot be suppressed by dense shade. However, in the dense evergreen forests which are its home, established regeneration thrives best if overhead light and free growing room are available ; otherwise stagnation sets in and growth is badly retarded. Evergreen shade of the top canopy layers is not so harmful, provided there is no undergrowth smothering the free development of *Mesua*.

The shade tolerance of *Mesua* makes it a valuable component of the middle storey of evergreen forests both in Assam and in the Western Ghats ; in both places it develops a large spreading crown, and in the former area *Mesua* often forms an understorey to *Dipterocarpus macrocarpus* in the *Hollong-Nahor* forest type, while in the latter area it occupies the second tier of the forest where the top canopy contains *Dipterocarpus indicus, Calophyllum elatum* and other trees.

Mesua is very sensitive to drought and its seedlings suffer severely in the dry season in exposed situations. It prefers a deep, moist, fertile soil and can withstand moderately heavy soil provided drainage is free. It is sensitive to frost but there is no frost in its natural habitat. It is easily killed by fire. Both young and old trees of *Mesua* are subjected to the attack of a root fungus which in Assam kills them in groups. The coppicing power of *Mesua* is generally poor, but there are instances in which young trees standing isolated have thrown off vigorous coppice shoots, and that repeatedly, on cutting back. Light seems to play a decisive role in the process. Kanjilal (Troup I, p. 26) has reported that in the Hollongapar Reserve of Sibsagar Division, Assam, trees of 12 to 24 inch girths failed entirely to coppice. Jogeswar Sur (*Ind. For.* IX, 1883, p. 609) found that a young tree when burnt down threw out strong shoots from the collum. Troup mentions of 3 young plants standing in front of Kulsi rest-house, which threw off new shoots as often as they were cut back. An experiment conducted for finding out the effect of coppicing young seedlings 2 to 5 years old in Chenat Nair Reserve, Palghat, Madras, indicated that coppiced seedlings though standing in the open, put on comparatively little growth, as detailed below :—

Mesua ferrea : Height growth of coppiced seedlings compared to whole seedlings

Date of coppicing	Coppiced natural seedlings, average height		Natural seedlings not coppiced, average height	
	Dates of measurement			
	13–9–1925	18–10–1927	13–9–1925	18–10–1927
	ft. in.	ft. in.	ft. in.	ft. in.
May 1920	3 10	6 6	7 4	9 7

There appear to be certain varietal differences in the trees of different localities, which find expression in the colour of the earliest leaves which emerge from the germinating seed. These leaves are dark blue in the Kodamadi region of Tirunelvely District, Madras and in the Hassan Ghats of Mysore; they are deep pink in the Silent Valley Reserve of Palghat Division, in the Nilgiris, in the Agumbe–Kilandur zone of Mysore as well as in parts of Assam. In some other localities, e.g., parts of North Kanara in Bombay, and Assam the earliest leaves are pale green. It is believed that the deep blue leaves indicate trees whose heartwood is of black colour, while the pink and pale green ones indicate typical, dark red to reddish brownish heartwood. It is also known that in some localities the white bloom found on the under surface of *Mesua* leaves is absent. Twisted fibre and interlocked grain are found in *Mesua* (Fig. 3) and they are also believed to be inherited (Proc., VIII Silv. Conf., Dehra Dun, 1951).

Regeneration : natural and artificial—(i) *Natural reproduction*—As a rule, in the forests where it occurs both in Assam and in the Western Ghats of Deccan, the tree regenerates more profusely than most of its associates with the exception, probably, of *Poeciloneuron indicum* in the latter locality. The abundance of natural reproduction is probably due to the following factors :

(*i*) abundant seeding of the tree in favourable situations, (*ii*) the large amount of food material stored in its cotyledons which remain underground and continue to feed the seedling for many months, (*iii*) the remarkable power which the

seedlings of *Mesua* possess to persist in shade and withstand the competition for light and space in evergreen forests, (*iv*) the ability of the regeneration to respond to release even after an indefinite period of suppression. The two essential conditions required for the germination of seed and early development of the seedling namely, high degree of moisture and protection from the sun, are both given to it in evergreen forests.

Mesua trees seed abundantly in those areas where it is the dominant tree and its trees have free, well developed crowns ; in such places there is no difficulty in obtaining sufficient regeneration under mother trees. Where, however, the tree forms an understorey to larger trees of other kinds the seed crop is not very abundant and regeneration is often poor. In such places, if left undisturbed, the crop may be able just to maintain itself.

On the ground, the seed of *Mesua* is exposed to various dangers. Germinating or other seeds exposed to the sun soon dry up killing the embryo. The seed is destroyed by weevils or devoured by pigs, porcupines and other animals. In Assam, they are also collected by the local inhabitants for burning. As a result of all this a good seed year is not necessarily always a good seedling year.

Once established, however, the seedlings can withstand any amount of shade, and they can tolerate this condition for a long time though they cannot progress. Recent experiments in Wynaad, Madras, aiming at inducing natural regeneration of *Mesua* have shown that clearing of weed growth and forking of the soil induces natural reproduction. (Silv. Res. Rpt., Madras, 1948–49 and 1949–50). Removal of competing underwood is beneficial as this promotes height growth of established plants and also expedites establishment. (Silv. Res. Rpt., Madras, 1951–52, p. 10).

In evergreen forests where the upper canopy has been disturbed by fellings, regeneration of *Mesua*, under mother trees is profuse, but systematic cleaning will be necessary to help the seedlings and saplings to develop into poles and adult trees. In general, it may be stated that given this assistance there is no difficulty for *Mesua* saplings to compete with the regeneration of their faster growing but more light loving associates. The smothering effect of the dense undergrowth in evergreen forests is often the principal enemy of the young natural regeneration, not the overhead shade. (K. Kadambi, Working Plan, 1945, p. 60).

The natural reproduction of *Mesua* forests has been the subject of a lot of experimental work in the North-Eastern Frontier Agency forests of the *Hollong-Nahor* type in Assam ; the following inferences have been drawn from the experiments :—

> In well stocked *Hollang-Nahor* forests, where the middle storey mainly consists of *Mesua* sufficiently big gaps must be opened up in the top storey retaining the lower storey to keep down weed growth. *Mesua*, with its longer seed viability and shade bearing habits has a distinct advantage over *Dipterocarpus macrocarpus* and as such will regenerate itself without much looking after. As the seedlings gradually develop, the lower middle storey should be opened up in stages to remove congestion. In poorly stocked areas with scattered trees in the top canopy and a certain amount of middle aged and pole crops, the lower middle storey has to be manipulated to free the existing poles and saplings, and shrub cutting also should be done to free the suppressed regeneration.

In areas where bamboo forms the main undergrowth the seedlings should be freed by cutting bamboo. (Silv. Res. Rpt., Assam, 1948–49, para 5).

(ii) *Artificial regeneration*—The tree can be raised artificially by direct sowing or by transplanting of medium sized or large transplants with naked roots (Madras) or with balls

of earth (Assam and Bengal). Stump planting is not advantageous. It appears that, if introduced in the open, sowing will do very well, but if under top canopy shade planting is preferable.

In Assam both direct sowing or transplanting with balls of earth have been tried; direct sowing has done better than transplanting in Holangapar Reserve, Sibsagar Division (R. N. De).

In Bengal, direct sowing in lines 6 feet apart with 2 rows of seed in each line and transplanting with balls of earth of second year seedlings have been tried on an experimental scale with success (C. K. Homfray). Direct sowing seems to be the better method for Bengal and it has been preferred to transplanting.

In Madras both direct and sowing transplanting under top canopy have met with success, though in several instances the latter method appeared to be better. Direct sowing has sometimes proved a failure owing to overhead drip and splash, the absence of light also playing its own party by retarding germinations and development. (Silv. Res. Rpt., Madras, 1942–43, p. 54). Basket plants are also good. Medium sized and large transplants have given better success and height growth than small ones, and nursery plants are better than forest transplants. (Silv. Res. Rpt., Madras, 1942–43, pp. 50, 52). The best sowing date naturally varies with the annual weather conditions and the locality but, in general, April and May seems to be the suitable months for the localities Karianshola and Chandanatode (Silv. Res. Rpt., Madras, 1942–43, 1944–45), and the earlier the sowing can be done in the season, the better provided there is enough moisture. Sowing should not be done during the heavy rains of July as the plants are likely to suffer from heavy drip, but it may be done shortly after with moderate success. As regards planting, the best time appears to be mid-July for Karianshola and Chandanatode. (Silv. Res. Rpt., Madras, 1944–45).

Experimental evidence as regards the advantage or otherwise of burning is conflicting. Burning does not appear to be advantageous. In one instance in Wynaad, Madras, it was found that planted *Mesua* survived best under natural undergrowth without a burn, and the seedlings developed best in clearfelled forest without any cover crop or burn (Letter No. A. 1143/44, dated 4th July, 1944 of P.S., Madras; E.P. 27, Wynaad). On the contrary, in Karianshola, South Coimbatore Division, *Mesua* did best in clearfelled and burnt forest under a cover crop of *Tephrosia candida*. Both in Wynaad and Palghat the species has been successfully raised on an experimental scale in a deciduous, clearfelled and burnt forest under a nurse crop of *Tephrosia candida* and a shade crop of *Trema orientalis*. (Silv. Res. Rpt., Madras, 1950–51, para 13 and 1951–52, para 9).

(iii) *Nursery practice*—Nurseries should be made in the open and not under forest cover, as drip and splash are harmful to germinating seedlings. Fruits are generally collected from the ground in Assam and Madras or sometimes from the tree in Bengal. They are spread out in the sun until they dehisce and then dried in shade (Bengal). Seed can be stored in gunny bag for a year (Homfray and De). In Madras they are known to keep good only for 5 months, the germination dropping to 30 per cent at 6 months. (Silv. Res. Rpt., Madras, 1940–41). The longevity of the seed in storage has much to do with the condition of the seed at the time of storing; well dried seeds store better. Seed weight varies within wide limits from 130 (Bengal, Homfray) to 200 to 600 (Wynaad, A. N. Sarma) per pound. Germinative capacity of seed is excellent, 95 per cent having been recorded in nursery beds (93 per cent, F.R.I., Sen Gupta), and 75 per cent when directly sown in the forest under *Tephrosia candida* in Bengal. In Madras the maximum germinative capacity is given as 70 per cent, the plant per cent being 68. (Silv. Res. Rpt., 1939–40, para 42). According to Madras reports germination may take place in the second year but this needs confirmation.

No variation has been found in the germinative capacity of seeds collected in the same place during different parts of the fruiting season, though it is stated that in portions of Madras, seeds collected in the third week after seedfall begins, give the best germination. Provided there is enough moisture the seed germinates better in the open than in shade, but being extremely sensitive to drought the seedling may suffer as a result of the sun ; shaded beds are, therefore, preferable. Seedlings raised in nursery beds situated in the forest would appear to suffer from drip ; lack of adequate light in such situation also retards their development.

In Bengal and Assam the seeds are sown in shaded nursery beds. In Bengal the seeds are placed on their edges 3 × 3 inches apart and at a depth equal to the diameter of the seed and covered over with a thin layer of earth ; 7 lbs. of seed are sown per bed 12 × 6 ft. in size. Growth is stated to be slightly better in shaded than in open beds (Homfray). Germination commences in about 10 to 14 days and is complete within about 2 months or less. In Bengal the seedlings are pricked out into shaded beds 4 × 4 inches apart as soon as they are big enough to handle. Manuring the beds with leaf mould is known to help but this is not essential (Homfray). In Madras better results have been obtained from unburnt than from burnt nursery beds. Weeding is advantageous and gives better development to seedlings. (Silv. Res. Rpt., Madras, 1929–30).

In Bengal planting is done in pits 1 ft. cube. A planting distance of 6 feet has been recommended for *Mesua*. *Boga-medeloa* is sown in-between the lines of *Mesua* in the first year. If *Boga* grows too thick it is necessary to thin it out and also to prune its branches in the second year.

Weeding is essential and will hasten the establishment of seedlings. *Mesua* being a slow grower, weeding will be needed for 6 to 7 years before establishment (R. N. De).

The earliest record of forest plantations of *Mesua ferrea* is of those formed in the Nambhor reserve of Sibsagar Division, Assam between the years 1876–7 and 1882–3 ; these were eventually abandoned, The plantations were formed by sowing seeds of *Mesua ferrea, Lagerstroemia flos-reginae* and *Cedrela toona* 6 feet apart. Presumably *Cedrela toona* did not succeed. In 1903, the plantations are reported to have been very densly stocked with young poles whose average girth was 2 feet, and also the poles of *Lagerstroemia flos-reginae* greatly outnumbered those of *Mesua*. In 1877, a small plantation of *Mesua* was raised by sowing seed adjoining the Kapti rest-house, E. Bengal. In the Wynaad Ghat forests of Madras, regeneration of *Mesua* in mixture with various other evergreens has been tried in the felling gaps with indifferent success (A. N. Sarma). At Nilambur, Madras, underplanting *Mesua* in an open teak plantation 73 years old has given good results. (For. Res. Rpt., Madras, 1928–29, e. 1).

Mesua will be useful as second storey crop in plantations of fast growing and light demanding trees in which the canopy opens up early and an understorey will be advantageous. In such cases *Mesua* could be introduced along with the light loving, main species in alternate line mixtures (Homfray).

METHODS OF MANAGEMENT

Mesua forests are worked generally under the "Selection" and "Shelterwood" methods. The former has been prescribed for some *Nahor* type forests of Assam in which the tree occurs in almost pure, uneven-aged patches and for some evergreen forests of the Western Ghats of Mysore, Travancore-Cochin, the Anamalais and the Western Ghats of Madras where exploitation is confined to a few marketable species only. The "Shelterwood" method generally, has been prescribed for the *Hollong-Nahor* forests of Assam, and for the heavily worked portions of the evergreen ghat forests of Mysore where the copious natural reproduction and advance growth which have resulted from past exploitation are in need of help.

The *Nahor* forests of Assam contain nearly pure patches of unevenaged *Mesua* with abundant immature stock, and the "selection" method involves no sacrifice of such stock and is not also incompatible with the silvicultural requirements of *Mesua* which is a shade bearer. The ghat evergreen forests of Mysore and Madras are worked for sleepers, of *Dipterocarpus indicus* (Mysore) or *Mesua ferrea* (Madras) and for poles of *Poeciloneuron indicum* and *Mesua ferrea* (Mysore) for which no method other than the selection of suitable mature trees appears to be appropriate. In the *Hollong-Nahor* forests there is abundant advance growth of these two valuable species whose subsequent growth depends on the admission of light by the removal of the overwood, underwood and the unwanted undergrowth by successive fellings and cleanings. In the ghat forests of Mysore, where as a result of former fellings the canopy has been opened out and abundant advance growth of saplings and poles are thronging the lower canopy and awaiting release from suppression of the unmarketables, this is secured by lifting the canopy from below upwards in three stages : in the '*initial*' stage the underwood and undergrowth are removed, in the *intermediate* stage the middle layers of the canopy are felled and in the *final* stage all overwood stems of the valuable species over and above a certain size are felled, this size being 5½ feet for *Mesua* (Kadambi's Working Plan, 1941–61, p. 137).

External dangers—The seed of *Mesua* is attacked and destroyed by a weevil ; it is also eagerly devoured by pigs, porcupines, hanuman monkeys, malabar squirrels (Mysore) and the like, thus hampering natural reproduction. In Bengal, rats damage the seedlings in the nursery. In the Tirunalvelly *cum* Ramnad Divisions of Madras *Mesua* saplings and poles are damaged by a *cerambycid* borer which is reported to make longitudinal and radial tunnels in almost every tree over 1 foot in girth, rendering the wood quite unfit for conversion into railway sleepers. An unidentified fungus kills *Mesua* trees of all sizes in the forests of Assam in patches, and in the Western Ghat forests of Mysore and Madras the same fungus, presumably, kills individual trees.

Rate of growth of Mesua and volume figures—*Mesua* is a slow grower. Seedlings in Bengal attain heights of 1 foot, 2½ feet and 3½ feet respectively in the first three years (Homfray). Various measurements made in connection with silvicultural experiments in Madras confirm the above statement :

Mesua ferrea. Rate of growth in nurseries and experimental plots

Locality	Method of regeneration	Date or year of inspection of Expt.	Number of seasons or years of growth	Height ft. in.	REMARKS (canopy condition, etc.)
Chandanatode ..	Sowing seed	20th May	4 seasons	1 8·4	Nursery experiments.
Do. ..	Transplants	1937	8 years	2 9·0	
Karianshola ..	Sowing seed	1st June	4 seasons	1 8·8	
Do. ..	Do.	1937	2 seasons	0 7·6	
Do. ..	Transplants	1939	3 seasons	1 3·3	Evergreen top canopy shade and with *Boga* cover crop.
Palghat Div. plots ..	Do.	1924	16 years	6 3·0	Under evergreen canopy.

Mesua ferrea.—Rate of growth of planted seedlings.

Year	Condition of overhead canopy or shade crop														Method of regeneration
	Palghat Division						South Coimbatore Division								
	Tephrosia candida Mean height		*Trema orientalis* Mean height		Burnt, with *Tephrosia candida* Average height		Burnt, without *Tephrosia candida* Average height		Unburnt with *Tephrosia candida* Average height		Unburnt without *Tephrosia candida* Average height		Under growth intact; no burn Average height		
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	
1937	..	..	..	..	0	5·9	0	6·3	0	6·8	0	6·7	0	6·9	
1938	..	..	..	..	0	5·8	0	6·4	0	6·5	0	5·6	0	6·3	Transplants in all cases
1939	..	..	..	..	0	7·7	0	7·7	0	8·7	0	8·2	0	7·3	
1940	..	..	..	..	0	10·9	0	9·0	0	11·2	0	7·7	0	8·6	
1941	0	5·7	0	5·1	1	0·9	0	7·5	0	7·4	0	7·4	0	9·4	
1942	0	9·0	0	10·6	1	3·0	1	0	1	8·0	1	1·0	0	11·0	
1943	0	9·6	0	10·4	2	0·3	2	2·7	2	4·8	2	3·9	1	2·3	
1944	1	9·9	1	1·8	3	3·8	3	7·0	3	7·5	3	4·1	1	6·2	
1945	0	11·0	0	10·6	4	1·7	5	2·0	4	1·9	4	4·4	1	10·7	
1946	2	4·1	1	5·1	6	0·5	6	5·0	5	5·7	5	5·2	3	8·6	
1947	4	0·1	2	4·4	7	3·0	8	8·0	7	7·0	8	0	4	2·0	
1948	5	6·3	4	7·0	10	6·0	12	6·0	10	5·0	9	10·8	5	1·2	
1949	7	8·6	6	3·8	12	8·0	14	10·7	11	7·2	11	3·6	5	8·4	
1950	9	8·2	9	8·5	14	5·0	17	6·0	13	7·2	13	5·0	6	10·8	

The two Palghat plots were in clearfelled and burnt deciduous forest, which was originally an evergreen forest but had regressed to deciduous condition owing to maltreatment. The South Coimbatore plots were all in clearfelled, evergreen forest.

Mesua ferrea. Height growth of planted stock of known age under full evergreen cover, (E.P. No. 42/1937), Wynaad Division, Madras

Year of measurement	Age in years	Survival %	Mean height in.	Increment during year in.
1937	4½	100	22·92	..
1938	5½	100	26·09	3·17
1939	6½	100	29·98	3·89
1940	7½	100	33·00	4·02
1941	8½	97	35·57	2·57
1942	9½	97	40·08	4·51
1943	10½	97	45·58	5·58
1944	11½	90	48·30	2·70
1945	12½	90	55·75	7·45
1946	13½	86	63·50	7·75
1947	14½	86	68·07	4·57
1948	15½	86	84·90	16·83
1949	16½	73	89·47	4·57
1950	17½	20	105·80	16·33

Mesua ferrea. Height growth of planted stock of known age under full evergreen cover (E.P. No. 147/1935), Palghat Division, Madras

Year	Age (years)	Survival %	Mean height ft.	Increment during the year ft.
1935	11	100	4·70	..
1936	12	100	4·96	·26
1937	13	100	5·18	·22
1938	14	100	5·78	·60
1939	15	100	6·25	·47
1940	16	100	6·88	·63
1941	17	100	7·23	·35
1942	18	98	7·86	·63
1943	19	98	8·30	·44
1944	20	98	9·30	1·00
1945	21	98	9·90	0·60
1946	22	95	11·30	1·40
1947	23	98	11·50	0·20
1948	24	96	11·50	Nil
1949	25	96	12·30	0·80
1950	26	96	13·70	1·40

Height growth of natural seedlings and saplings situated under natural evergreen forest cover is also very slow as seen by the following measurements taken in the "Natural Regeneration Tending" plots, Agumbe State Forest, Shimoga Division, Mysore State :—

Mesua ferrea. Height growth of forest saplings (age not known) under evergreen forest cover

Date of measurement and height									
28–5–38		28–11–38		27–4–39		May, 1940		May, 1941	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
9	2	9	5	9	5	9	7	9	11
6	1	6	2	6	6	6	7	7	10
5	9	5	9½	5	9½	5	11	6	7
10	0	10	0	10	4	10	8	11	0
14	0	14	1	14	1	14	2	14	8
7	1	8	10	9	5	9	6	9	8
2	7	2	7	2	7	2	9	2	11
4	2	4	2	4	3	4	6	5	2
4	5	4	5	4	5	4	6	4	7

The following height and diameter growth figures of *Mesua* trees grown in the silvicultural garden at Sukna, W. Bengal are on record :—

Mesua ferrea. Rate of growth in plantation (Silv. Res. Rpt., W. Bengal, 1949–50, p. 36)

Year of planting	Height growth maximum		Average		Average girth at breast height		Remarks
	ft.	in.	ft.	in.	ft.	in.	
1942	30	0	23	0	0	8	Healthy

The measurements recorded for the Oghuri plantation, Sibsagar, Assam, show that *Mesua ferrea* attains an average breast height girth of 2 feet in 24 years representing a mean annual girth increment of 1 inch a year. In the circuit house at Sibsagar it is recorded that trees 48 years old had attained girths of 50 inches. From indirect evidence relating to Nambor forest reserve, trees 7½ feet in girth have been reckoned here to be not less than 100 years old.

Mr. Purkayastha, in his Working Plan for the plains reserves on the south bank of Brahmaputra River in Lakhimpur Division, Assam and in his Assam Forest Records, Vol. II – 1934 has recorded the following figures on the rate of growth of *Mesua ferrea* in Assam.

Mesua ferrea. Current annual increment in girth at breast height

Girth class inches		No. of trees measured	Average C.A.I. in girth	No. of years required to grow 3 in. in girth by the average tree of the class
from	to		in.	
6	9	87	0·390	8
9	12	174	0·405	7
12	15	154	0·415	7
15	18	109	0·427	7
18	21	94	0·438	7
21	24	78	0·450	7
24	27	72	0·459	7
27	30	48	0·468	6
30	33	51	0·480	6
33	36	62	0·490	6
36	39	53	0·502	6
39	42	34	0·511	6
42	45	30	0·521	6
45	48	35	0·532	6
48	51	31	0·543	6
51	54	37	0·553	5
54	57	25	0·564	5
57	60	13	0·575	5
60	63	11	0·586	5
63	66	15	0·597	5
66	69	11	0·607	5
69	72	5	0·618	5

The following table gives the current annual diameter increment based on two re-measurements at 5-year intervals from sample plot No. 4 of Lakhimpur Division, Assam.

Mesua ferrea. Diameter increment

Diameter class	Average C.A.I. in diameter
in.	in.
4– 8	0·30
8–12	0·46
12–16	0·53
16–20	0·59
20–24	0·65

The working plan for the Wynaad Ghat Forests, Wynaad Division, Madras, by A. N. Sarma records the following growth figures.

Mesua ferrea. Girth increment

Girth	Age
in.	year
18	20
36	40
54	60
72	90

The working plan for the ghat forests of Shimoga and Sagar Divisions, Mysore by K. Kadambi records the following rate of girth increment.

Mesua ferrea. Rate of girth increment

Girth class	Annual increment	Estimated No. of years required to grow 6 in. in girth
ft.	in.	
0 –1½	0·32	..
1½–3	0·33	18
3 –4½	0·38	15
4½–6	0·34	17
6 –7½	0·28	..

From the statistics available, Purakayastha has arrived at a rotation of 140 years for an exploitable size of 5½ feet in the forests of the south bank of the Brahmaputra River, Assam, while Kadambi has estimated that it takes 174 years for the same exploitable size in the ghat forests of Shimoga and Sagar Divisions, Mysore. Sarma has reckoned provisionally that the tree can attain a girth of 6 feet in 90 years in the Wynaad Ghat forests. It is likely that the tree can grow much faster in plantations than in natural forest where it suffers from the pressure of heavy overhead shade for an indefinitely long period in its earlier life.

Volume and out-turn tables for *Mesua ferrea* have been compiled by Purakayastha and published in the Assam Forest Records, Vol. II (Silviculture); the following tables are extracted from them.

Mesua ferrea.—Full Volume tables

Girth classes	Height Classes in Feet: 41–60 — No. of stems meas-ured	41–60 — Actual average volume	41–60 — Volume as read off from the curves	61–80 — No. of stems meas-ured	61–80 — Actual average volume	61–80 — Volume as read off from the curves	81–100 — No. of stems meas-ured	81–100 — Actual average volume	81–100 — Volume as read off from the curves	101–120 — No. of stems meas-ured	101–120 — Actual average volume	101–120 — Volume as read off from the curves	Average volume for locality
1	2	3	4	5	6	7	8	9	10	11	12	13	14
feet	No.	c. ft.	c. ft.	No.	c. ft.	c. ft.	No.	c. ft.	c. ft.	No.	c. ft.	c. ft.	c. ft.
3–4	1	22·2	22·0	10	27·5	27·0	2	28·1	34·5	..	..	..	27·0
4–5	3	35·2	33·5	109	39·7	40·5	37	47·2	47·0	..	..	..	41·0
5–6	1	47·0	47·5	23	54·5	56·5	104	66·9	67·0	4	92·3	83·5	65·0
6–7	..	..	68·5	5	103·2	81·0	69	97·3	97·8	15	118·5	118·5	101·5
7–8	..	..	..	5	138·2	119·6	48	140·3	140·0	19	149·7	160·0	141·5
8–9	..	..	..	5	153·6	168·0	10	186·2	186·0	8	216·0	209·0	109·0

Mesua ferrea.—Outturn Tables

Girth classes	Height Classes in Feet: 41–60 — No. of stems meas-ured	41–60 — Actual average number of M.G. sleepers	41–60 — No. of M.G. sleepers as read off from the curves	61–80 — No. of stems meas-ured	61–80 — Actual average number of M.G. sleepers	61–80 — No. of M.G. sleepers as read off from the curves	81–100 — No. of stems meas-ured	81–100 — Actual average number of M.G. sleepers	81–100 — No. of M.G. sleepers as read off from the curves	101–120 — No. of stems meas-ured	101–120 — Actual average number of M.G. sleepers	101–120 — No. of M.G. sleepers as read off from the curves	Average number of M.G. sleepers for the locality
1	2	3	4	5	6	7	8	9	10	11	12	13	14
feet													
3–4	1	3·1	3·1	10	3·8	3·8	2	4·8	4·8	..	..	..	3·8
4–5	3	5·0	4·8	109	6·3	6·2	37	8·3	7·8	..	..	..	6·8
5–6	1	5·9	7·1	23	9·3	9·1	104	11·7	12·0	4	18·2	15·8	11·2
6–7	..	..	10·1	5	19·9	13·2	69	17·0	17·0	15	23·4	21·5	17·4
7–8	..	..	..	5	21·2	17·8	48	23·0	22·2	19	25·8	27·3	23·6
8–9	..	..	..	5	25·2	22·2	10	24·8	27·5	8	32·2	33·0	30·0

Mesua ferrea. Commercial outturn Tables

	Commercial outturn in round timber			Commercial outturn in sawn timber		
Girth classes	Number of stems measured	Actual average volume in c. ft.	Volume as read off from curves in c. ft.	Number of stems measured	Actual average volume in c. ft.	Volume as read off from curves in c. ft.
1	2	3	4	5	6	7
feet						
3– 4	18	18·12	22·00	..	..	..
4– 5	82	32·48	32·50	63	12·3	12·7
5– 6	151	44·38	44·50	74	19·0	19·0
6– 7	163	55·45	57·50	48	25·1	26·0
7– 8	76	70·27	70·65	18	28·8	33·8
8– 9	59	84·73	84·00	5	44·1	41·0
9–10	21	117·92	97·00	..	..	..

The following local commercial volume table was compiled for *Mesua* in the Perya Reserve of Wynaad, Madras, by the Provincial Silviculturist, Madras :—

Mesus ferrea. Local commercial volume tables showing outturn of timber in the log fit for sleeper conversion, Perya Reserve, Wynaad, Madras

Girth classes at breast height in feet	No. of trees measured	Yield in c. ft.
2– 3	..	12·0
3– 4	12	23·5
4– 5	16	37·5
5– 6	14	53·5
6– 7	105	72·5
7– 8	120	93·0
8– 9	121	115·0
9–10	71	138·0
10–11	70	160·5
11–12	42	183·5
12–13	19	206·0
13–14	10	229·5
14–15	8	252·0
15–16	6	275·0
16–17	4	297·0
17–18	1	320·0

The following average volume table was compiled by T. V. Venkateswara Ayyar for the Palghat ghat forests, Palghat Division, Madras.

Mesua ferrea. General average volume table

Number of trees measured (1)	Girth class in feet (2)	Gross volume in cubic feet (3)	Net volume in cubic feet (4)	Diameter class in inches (5)	Gross volume in cubic feet (6)	Net volume in cubic feet (7)
24	5– 6	44	21	16–20	34	17
628	6– 7	57	27	20–24	47	23
1,100	7– 8	72	34	23–24	52	25
1,033	8– 9	90	42	24–28	62	29
660	9–10	110	52	28–32	78	36
309	10–11	130	62	32–36	98	46
142	11–12	149	71	36–40	118	56
76	12–13	165	80	40–44	139	67
23	13–14	178	87	44–48	158	76
10	14–15	190	92	48–52	174	84

*Mesua ferrea. Volume table for Mesua in the Palaquium – Mesua association**

Girth class (breast height over bark) in feet (1)	Number of trees measured (2)	Gross outturn in the round in cubic feet (3)	Net outturn (sleepers) in cubic feet (4)
3– 4	..	22	10
4– 5	..	30	15
5– 6	108	40	20
6– 7	108	*52*	*25*
7– 8	255	*66*	*30*
8– 9	413	*82*	*38*
9–10	213	*102*	*50*
10–11	86	*124*	*62*
11–12	30	144	72
12–13	16	156	78
13–14	4	166	82
14–15	..	173	85
15–16	1	180	87

* Values not in italic types are tentative.

The following figures of average volume of timber in cubic feet and outturn of sleepers in Broad Guage units for *Mesua* in the Kal-Ar valley of South Coimbatore Division prepared by the Provincial Silviculturist, Madras, are extracted from A. N. Sarma's Working Plan of the forests of South Coimbatore Division, Madras.

Mesua ferrea. A local assortment table for trees in the Kal-Ar valley
(Prepared from data of actual outturn from 985 trees)

NOTE.—Figures for trees of 10 feet girth and over are not accurate and must be used with caution.

Breast height girth over bark		Volume of timber in cubic feet	Outturn oı sleepers in B.G. units	Breast height girth over bark		Volume of timber in cubic feet	Outturn of sleepers in B.G. units
(1)		(2)	(3)	(1)		(2)	(3)
ft.	in.			ft.	in.		
4	0	26	4·5	12	3	152	20·5
4	3	28	4·9	12	6	154	21·0
4	6	31	5·3	12	9	156	21·3
4	9	33	5·7	13	0	158	21·8
5	0	36	6·2	13	3	160	22·0
5	3	40	6·7	13	6	162	22·3
5	6	43	7·2	13	9	163	22·8
5	9	46	7·8	14	0	165	23·0
6	0	50	8·3	14	3	166	23·3
6	3	55	8·9	14	6	168	23·5
6	6	59	9·4	14	9	169	23·8
6	9	64	10·1	15	0	170·5	24·3
7	0	68	10·7	15	3	172	24·5
7	3	73	11·3	15	6	173	24·8
7	6	78	11·9	..		..	..
7	9	84	12·6	15	9	174·5	25·0
8	0	88·5	13·6	16	0	176	25·0
8	3	93	13·7	16	3	177	25·5
8	6	99	14·2	16	6	178	25·5
8	9	104	14·8	16	9	179	25·8
9	0	109	15·3	17	0	180	26·0
9	3	114	15·8	17	3	182	26·3
9	6	118·5	16·3	17	6	183	26·3
9	9	122·5	16·8	17	9	184	26·5
10	0	126	17·0	18	0	184·5	26·8
10	3	130	17·5	18	3	185	26·8
10	6	134	18·0	18	6	186	27·0
10	9	137	18·3	18	9	187	27·3
11	0	140	18·8	19	0	188	27·3
11	3	143	19·0	19	3	189	27·5
11	6	145·5	19·5	19	6	189·5	27·5
11	9	148	19·8	19	9	190	27·8
12	0	150	20·3	20	0	191	28·0

In his working plan for the Mount Stuart forests of South Coimbatore Division, Madras, M. V. Laurie has estimated the form factor of *Mesua ferrea* trees to be 0·87. His measurements were based on the statistics collected on 147 trees in this area.

The following commercial volume out-turn figures worked out by K. Kadambi from the range exploitation figures of Agumbe Range, Shimoga Division, Mysore for the years 1934 to 1939 are on record in the working plan for the ghat forests of Agumbe–Kilandur zone, 1941–61.

Girth class	No. of trees on which figures are based	Outturn of timber in the round	Outturn per tree
ft.		c. ft.	c. ft.
4–5	15	455	30·0
5–6	38	1,456	38·3
6–7	13	638	49·0
7–8	8	531	66·3

UTILIZATION

Supplies—Considerable quantities of the timber are available in Assam, the Jaipur forest being capable of an annual yield of 75,000 c. ft. or more and the Sibsagar Division of an equal quantity. Moderate supplies are available from Malabar, Madras and Mysore. The Chenat Nayar reserve near Ovalakkot, Madras is estimated to yield from 20,000 to 22,000 c. ft. (C. E. Simmons) and the Uri Block in Coorg 9,300 c. ft. (Pearson & Brown, p. 58). In Mysore the ghat forests of Shimoga and Sagar are estimated to yield 15,080 c. ft. (K. Kadambi, Working Plan, p. 1945) while those of Hassan District for which no correct estimates exist will probably yield an equal if not a larger quantity.

Structure and properties of the timber—*Mesua ferrea* is an extremely heavy, straight or somewhat interlocked grained, even and medium-fine textured, dark red or reddish brown (or sometimes black) wood. It is the hardest, heaviest and strongest of the Indian woods of this family (Pearson & Brown, p. 59).

Weight at 12 per cent moisture content of sample from Sibsagar, Assam was found to be 60 to 65 lb. (60 lb. V. D. Limaye), of that from South India 67 lb. (up to 80 lb. Troup). *Mesua* is one of the strongest of timbers ; its strength compared to Burma teak, as determined by V. D. Limaya, is given in the following table :—

Mesua ferrea. Comparative suitability expressed as percentages of teak

	Weight at 12% moisture	Strength as a beam	Stiffness as a beam	Suitability as a post	Shock resisting ability	Retention of shape	Shear	Hardness	REMARKS
Burma Teak..	43	100	100	100	100	100	100	100	Sample from Sibsagar, Assam.
Mesua ..	60	145	150	150	160	55	145	215	

Mesua timber seasons slowly and is liable to crack even if converted green. The fibres being interlocked the cracks do not run straight but run more or less like those of sal. It is durable, untreated railway sleepers lasting 12 to 14 years (Pearson & Brown). Termites do not generally attack it. The wood is refractory to saw even when quite green and nearly impossible to saw if seasoned and in large sizes.

Uses—It is one of the premier constructional timbers of Assam and can be used in all situations where strength is of primary importance. In Bombay and on the west coast of Madras, it is not held in such high repute because equally durable but less refractory woods are available. The principal use of the timber is for railway sleepers, bridge construction and as posts and beams in building construction. It is not preferred for planking on account of its splitting and warping qualities, and further it is difficult to saw. It is also used, mainly in Assam and parts of E. Pakistan, for heavy furniture, carts, axles, yokes, shafts, ploughs, well construction, tool handles, *hookas* and the like. The wood has been tried for srevice rifle-stocks but found too heavy. The Nagas of Assam make bows out of it while in Chittagong (E. Pakistan) boats are made out of it and especially the parts keels, helms and masts. In the Kolar Gold Mines of Mysore it is used as undeground props for the tunnels and as head gear supporting the cage pully. In the steel rolling mills at Bhadravati, Mysore, it has been used for bearings. It is probably good for paving blocks. For firewood it is very good, its calorific value being high. At Agumbe, Mysore, its saplings are used to make capital walking sticks.

Minor Forest Produce—The kernels of the seed yield about 70 per cent of their weight of a somewhat perfumed, brown, clear oil which can be used for confectionary (Krishnamurty Naidu) and also medicinally as an embrocation in rhenmatism and for the treatment of itch. The unripe fruits are aromatic and sudorific. The flower buds cure cases of mild dysentry. Its leaf and flower are used in Bengal as anti-snake and scorpion venom, but chemical analyses have not disclosed any anti-venom constituents in them. The flowers are astringent and stomachaic. They are also used for cough. A paste made of the flowers with butter and sugar is used in bleeding piles and burning of the feet. An infusion of the bark and roots is considered an excellent tonic bitter. The bark is feebly aromatic and is considered a mild astringent.

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ILLUSTRATIONS

FRONTISPIECE.—*Mesua ferrea*, 21 feet 3 inches in girth with *Aglaia roxburghiana* and *Vateriai ndica* on the right and *Dichopsis*on the left. Periya R. F., Experimental Garden, Wynaad Division, Madras.

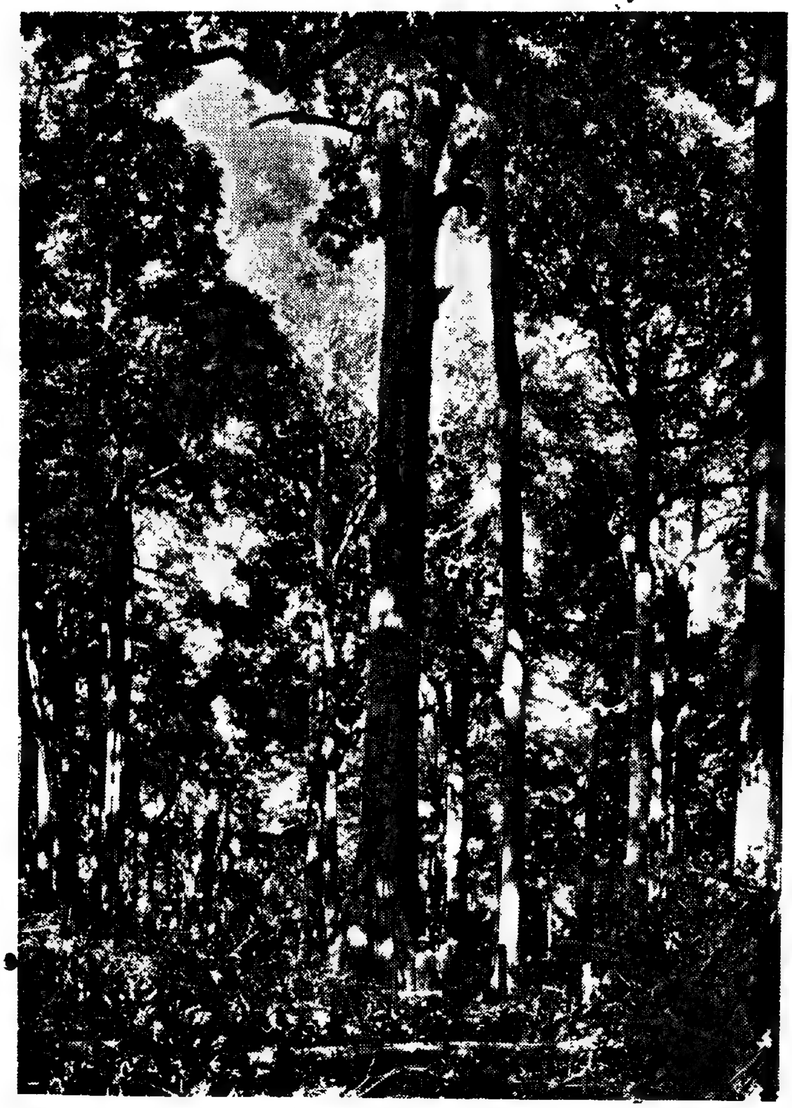
Photo – H. G. Champion, 1934.

FIG. 1.—Distribution of *Mesua ferrea* in India.

FIG. 2.—Both twisted and interlocked grain are found in *Mesua* timber. The old tree above shows right handed twist.

FIG. 3.—A Natural Seedling of *Mesua ferrea* which had remained suppressed for many years, in a recently created felling gap, showing how it produces new and vigorous leading shoots as a result of the opening. Chamdanatode, Wynaad Division, Madras.

Photo – M. V. Laurie, 1934.



FRONTISPIECE

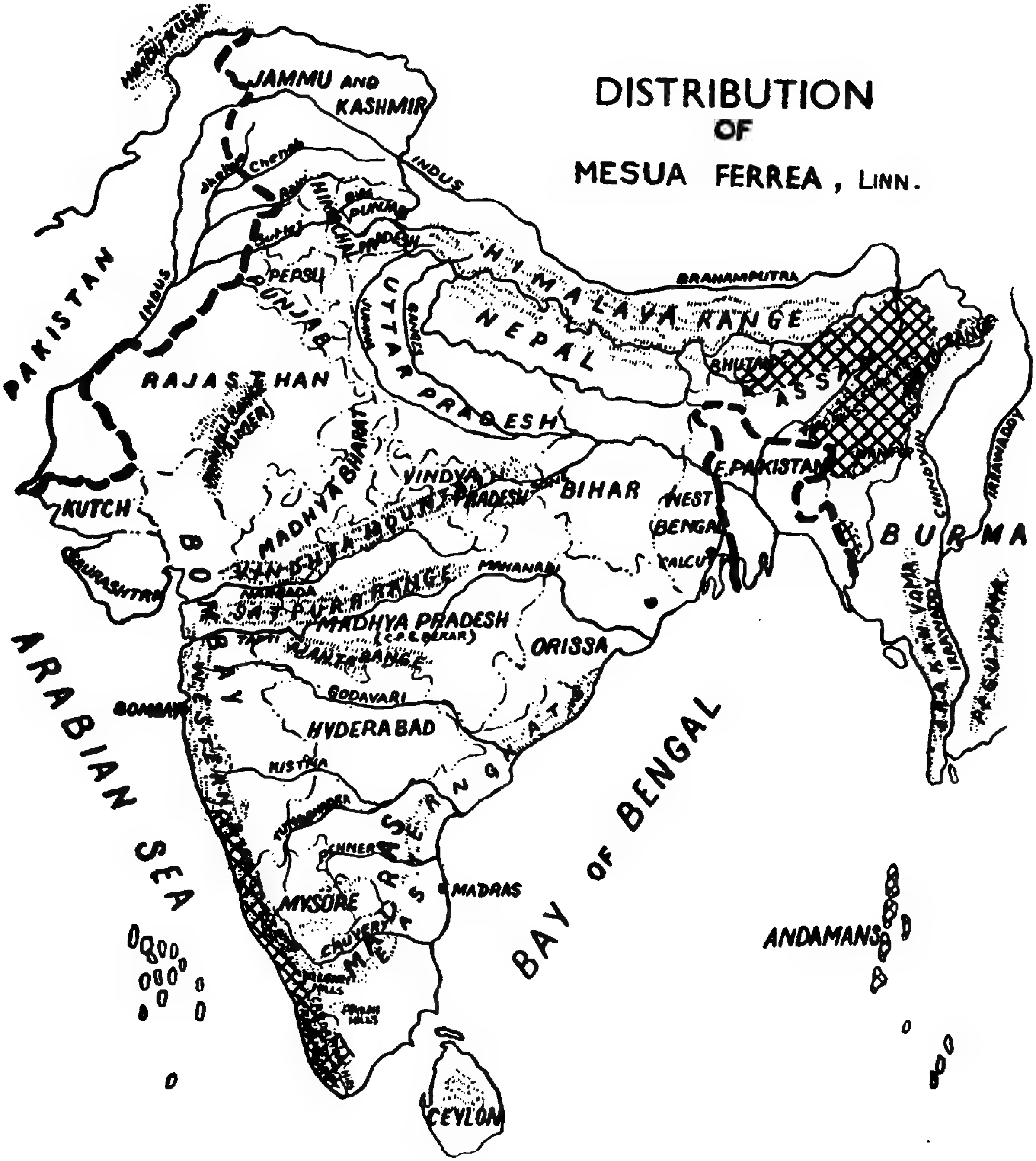

DISTRIBUTION
OF
MESUA FERREA, LINN.
JAMMU AND KASHMIR
INDUS
PAKISTAN
RAJASTHAN
PEPSU
PUNJAB
HIMALAYA RANGE
NEPAL
UTTAR PRADESH
BRAHMAPUTRA
BHUTAN
ASSAM
E.PAKISTAN
BIHAR
WEST BENGAL
CALCUTTA
BURMA
IRRAWADDY
CHINDWIN
KUTCH
SAURASHTRA
MADHYA BHARAT
VINDYA PRADESH
MADHYA PRADESH
ORISSA
BOMBAY
HYDERABAD
GODAVARI
KISTNA
MYSORE
MADRAS
CAUVERY
ARABIAN SEA
BAY OF BENGAL
ANDAMANS
CEYLON

FIG. 1

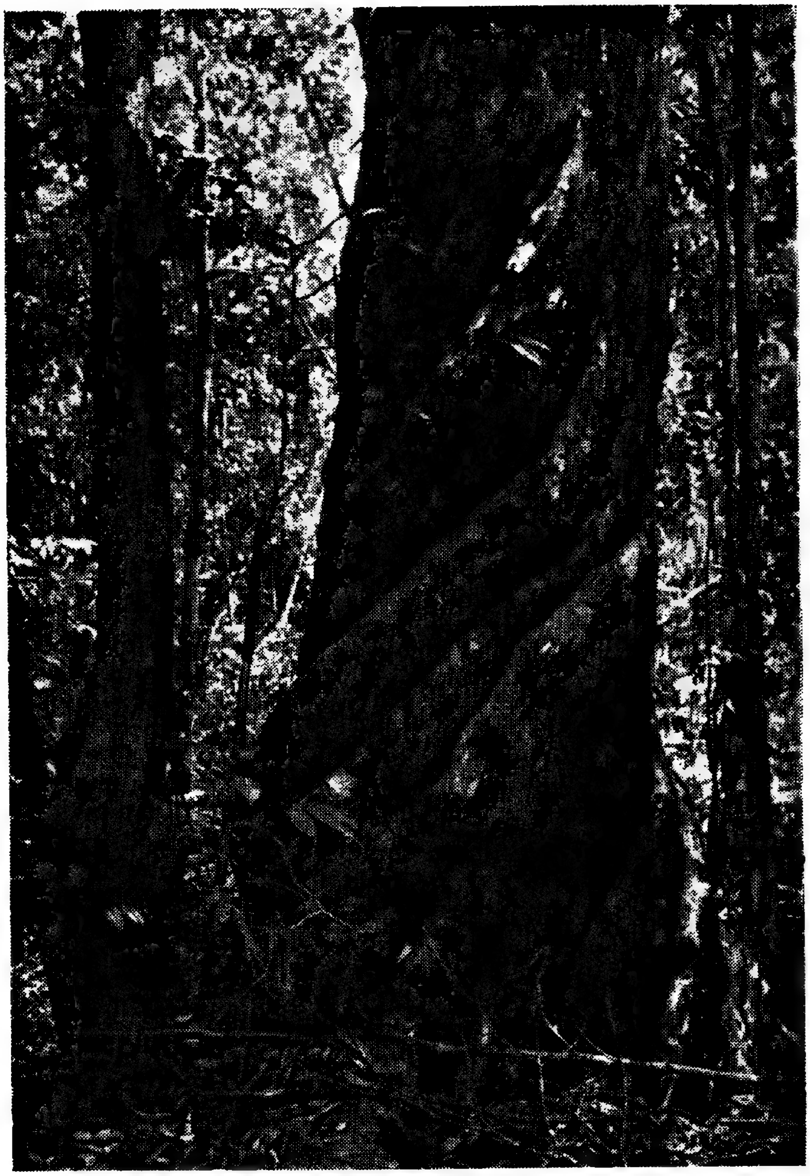


FIG. 2

FIG. 3

CHROMOSOME NUMBERS IN FOREST PLANTS*

BY H. S. RAO, D.SC., F.B.S.

Forest Research Institute, Dehra Dun

Chromosome numbers of forest species have been less often recorded than those of agricultural and horticultural plants. This is especially true of tropical and semi-tropical species which abound in India.

The chromosome numbers, and particularly the basic numbers prevailing through a genus or family are of primary interest in any consideration of genetic improvement of forest species. This is yet meagre knowledge compared with what is known of cultivated herbaceious plants, for most of which not only the mere number is known but also the morphology of the individual chromosomes, their aberrations affecting configurations, throwing light on the location of genes, and construction of cytogenetic chromosome maps.

The investigator of tree chromosomes has to be content with much less information because of inherent difficulty in the material. The size of chromosomes in tree species is as a rule very minute, and their number generally large. In view of the long span of the tree generations, the minute size and crowded nature of chromosomes offer little hope of fine cytogenetic correlations and gene-locations. The tree breeder has to be content largely with fortuitous accidents favourable to his purpose.

Until vastly improved microscopical techniques are available, the best one can hope for is just to make chromosome counts, and seize on any polyploid series that may be discovered. The staining techniques so often described by numerous technicians still fail to give a reliable schedule for tree species. Aceto-carmine methods while not so satisfactory, are the only main-stay. A fresh aceto-carmine preparation of pollen mother cells, while not spectacular, is often better than the sectioned material. Even with the generally brilliant crystal violet technique, our difficulty has been in retaining enough stain up to the final stage. Haematoxylin results in too dense figures. It has been practically impossible to make chromosome counts from somatic metaphase plates in leaf, petal or stem apex. We have not had much opportunity to make successful root-tip preparations. As for microscopy, we have been working with the maximum resolution and magnification available with a Bausch and Lomb objective 97X, and N.A. 1·25, and 10X or 15X oculars.

The time of day at which satisfactory division stages occurred baffled us for quite a while, when we sought for them from early morning till 2 p.m. Luckily, last spring and summer we hit upon a very short interval of about 15 to 20 minutes, from 3·55 to 4·15 p.m., when suddenly we came across first and second meiotic divisions taking place, under Dehra Dun conditions. Aceto-carmine which only gave unstained but opaque cytoplasm, seemed suddenly to "develop" the metaphase chromosomes. Most sketches were then immediately made. We have not had much success with making permanent slides from aceto-carmine mounts.

It has been, however, gratifying to record chromosome counts of a number of important Indian forest species and make the accompanying camera lucida drawings. A few cultivated species have also been included, which were principally used to try various techniques.

* Received for publication on 15-4-1954.

	Species	n number	2n number	Magnification
1.	*Ageratum conyzoides* Linn.	..	20	1400X
2.	*Bauhinia galpini* N. E. Br. ..	18	..	775X
3.	*Brassaia actinophylla* F. Muell. ..	12	..	775X
4.	*Butea monosperma* (Lamk.) O. Ktze (= *B. frondosa* Koen. ex Roxb.) ..	9	..	1400X
5.	Do. "yellow flowered" ..	9	..	1400X
6.	*Byrsonima crassifolia* H. B. K. ..	14	..	775X
7.	*Cassimiroa edulis* La Llave. & Lex. ..	..	18	1400X
8.	*Castanospermum australe* A. Cunn. ..	13	..	775X
9.	*Chloroxylon swietenia* D. C. ..	10	..	775X
10.	*Combretum coccineum* Lam. ..	28	..	775X
11.	*Diospyros peregrina* (Gaertn.) (= *D. embryopteris* Pers. Gurke) ..	15	..	775X
12.	*Eranthemum splendens* (T. And.) Brem. (= *Daedalacanthus splendens* T. And.)	12	..	1400X
13.	*Erythrina blakei* (Hort.)	21	..	775X
14.	*Helicteres isora* L.	12	..	775X
15.	*Hovenia dulcis* Thunb.	12	..	775X
16.	*Hydnocarpus kurzii* (King) Warburg (= *Taraktogenos kurzii* King) ..	12	..	775X
17.	*Jacaranda mimosaefolia* D. Don. ..	18	..	1400X
18.	*Lagerstroemia floribunda* Jack. ..	24	..	775X
19.	*L. speciosa* (L.) Pers. (= *L. flos-reginae* Retz.)	24	..	775X
20.	*Moringa oleifera* Lam. (= *M. pterygosperma* Gaertn.)	14	..	775X
21.	*Portulaca grandiflora* Hook. ..	9	..	775X
22.	*Rhus viminalis* Ait.	12	..	775X
23.	*Shorea robusta* Gaertn.	..	14	1400X
24.	*Solanum wightii* Bth. (= *S. macranthum* Dun).	..	12	775X
25.	*Tectona grandis* L. f.	..	24	1400X
26.	*T. hamiltoniana* Wall.	12	..	775X

Alongside the figures only the more familiar species names are given.

I am glad to acknowledge the assistance I received from Mr. P. C. Nanda, Research Assistant, in preparation of the material, especially by paraffin technique. My thanks are due to Mr. M. B. Raizada, F.N.I., for checking the nomenclature of the species.

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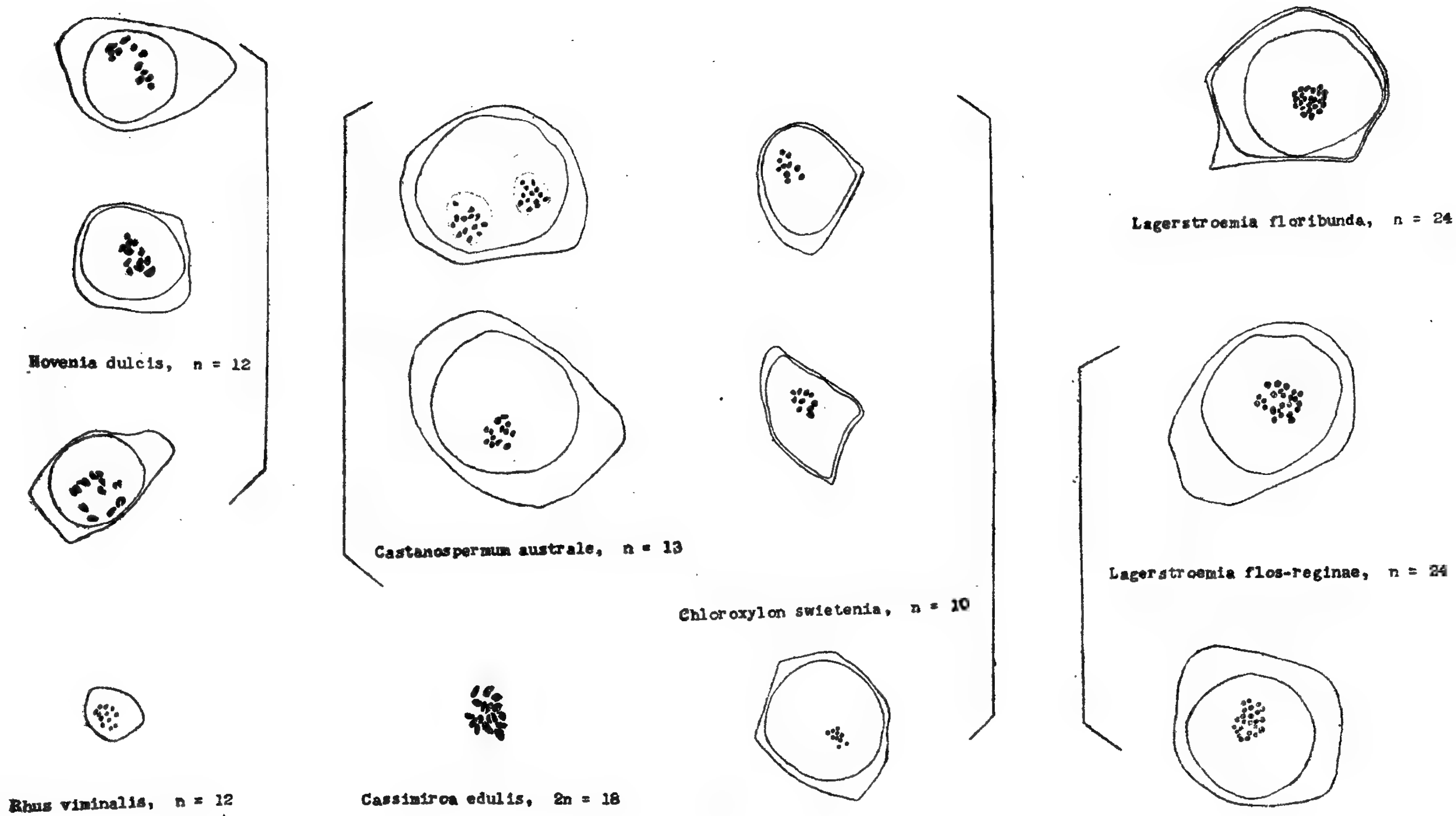
Hovenia dulcis, n = 12
Rhus viminalis, n = 12
Castanospermum australe, n = 13
Cassimiroa edulis, 2n = 18
Chloroxylon swietenia, n = 10
Lagerstroemia floribunda, n = 24
Lagerstroemia flos-reginae, n = 24

PLATE I

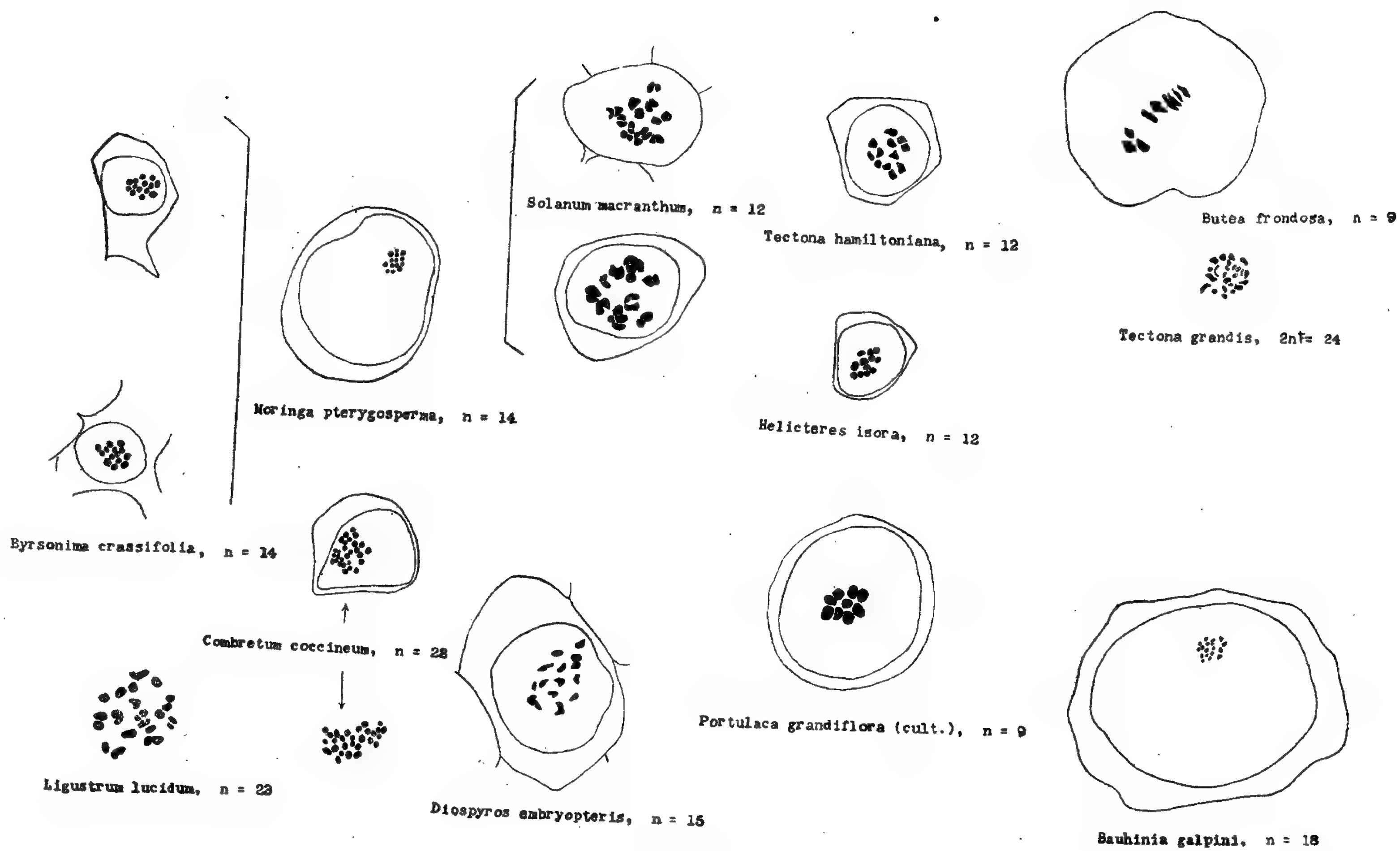
Byrsonima crassifolia, n = 14
Moringa pterygosperma, n = 14
Solanum macranthum, n = 12
Tectona hamiltoniana, n = 12
Butea frondosa, n = 9
Tectona grandis, 2n = 24
Helicteres isora, n = 12
Combretum coccineum, n = 28
Ligustrum lucidum, n = 23
Diospyros embryopteris, n = 15
Portulaca grandiflora (cult.), n = 9
Bauhinia galpini, n = 18

PLATE II

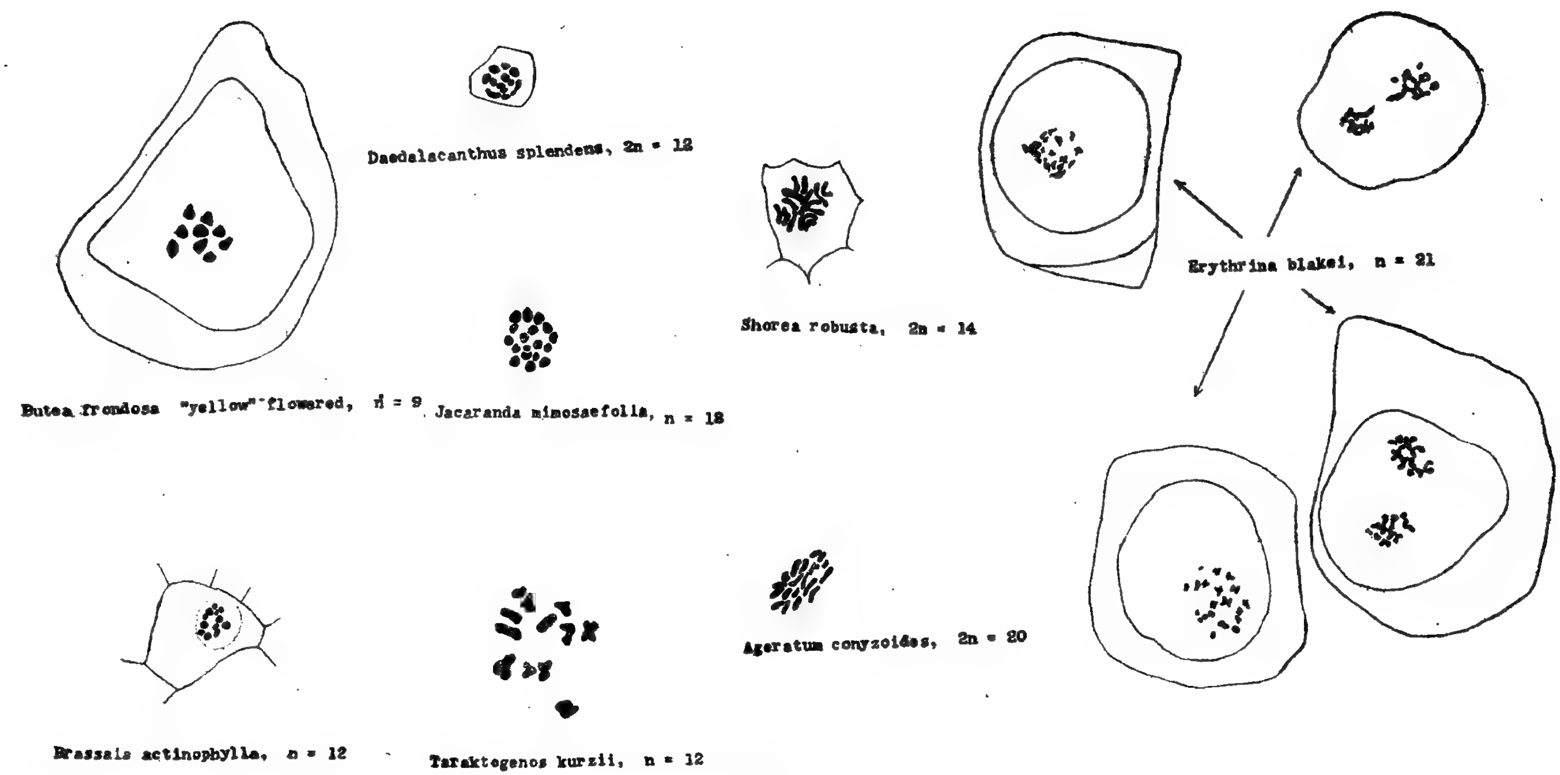
Daedalacanthus splendens, 2n = 12
Shorea robusta, 2n = 14
Erythrina blakei, n = 21
Butea frondosa "yellow" flowered, n = 9
Jacaranda mimosaefolia, n = 18
Ageratum conyzoides, 2n = 20
Brassais actinophylla, n = 12
Taraktogenos kurzii, n = 12

PLATE III

STRUCTURE OF EGG-MASSES AND THEIR HAIRS IN SOME SPECIES OF *LYMANTRIA* OF IMPORTANCE TO FORESTRY (INSECTA : LEPIDOPTERA : LYMANTRIIDAE)

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(With 1 Table, 1 Plate and 5 Text-figures)

I. INTRODUCTION

Species of the family Lymantriidae "appear as epidemics at intervals in forests of India and Burma and cause defoliation" (Beeson, 1941, p. 633). To be able to differentiate the species in the immature stages is a practical necessity because, in most cases, the adult moths are present in the field only for very short periods (sometimes only for a few weeks in the year) and the immature stages alone are generally available for examination. The larval stages of several species have been studied by Gardner (1938). Recently, an opportunity was provided for the study of the egg-masses of two important species of the genus *Lymantria,* namely, the following :—(*i*) *L. mathura* Moore, a serious pest of *sál* (*Shorea robusta*) and a few other species of trees in North India ; its population underwent a great eruption in the autumn of 1953 in the Doon Valley in the Western Sub-Himalayas (*vide* Roonwal, 1953). (*ii*) *L. obfuscata* Walker, a serious pest of willows (*Salix alba* and *S. fragilis*) in the Kashmir Valley. The egg-stage of these moths lasts for the major part of the year, so that it is important that one should be able to differentiate the species in that stage. In addition to these two species, the egg-mass of the Gypsy Moth, *L. dispar* Linnaeus, which is a serious pest of forestry in Europe and North America, was also available and was studied. It was found that the microscopic structure of the hairs covering the egg-masses is characteristic of each species and enables us to differentiate them. To a lesser extent, the shape, size and colour of the egg-masses also assist in the differentiation. In the present paper these aspects are discussed.

Acknowledgment—The measurements of the egg-mass hairs recorded here were largely taken by Shri Kumar Krishna, Research Assistant (I).

II. STRUCTURE OF EGG-MASSES AND EGG-MASS HAIRS

(*a*) *General*

Moths of the family Lymantriidae generally lay eggs in clusters on the surface of bark or leaves of trees, each egg-mass usually being covered externally with a felt-like layer of hairs believed to be derived from the anal tufts of the ovipositing female. In some species, however, the eggs are laid naked. The egg-mass hairs, where present, vary in colour from snow white, as in *Lymantria mathura* Moore (*vide infra*), to golden brown, dirty brown and earth-coloured. The outline of the egg-masses varies considerably, from subovoid to quadrate and semi-linear, the different shapes being prevalent within a single species.

The origin of the hairs covering the egg-masses is not well understood. Eltringham (1913) observed that in *Prothesia similis* Fuezzly the female moth collects the spicules, which are present on the cocoon, by brushing the latter with the anal tuft ; these spicules are then deposited over the egg-masses. This observation, however, requires confirmation. It is also known that the anal tuft of hairs in the female moth largely contributes to the hair-covering of the egg-masses of the Lymantriidae. Thus, Janjua (1950, p. 160) stated that in *Euproctis signata* Bl., of Baluchistan, which lays eggs on the upper surface of leaves of fruit trees, the egg-mass is covered over by a felt of brown hairs deposited by the female from its anal tuft,

The structure of the egg-mass hairs has not been studied, except by Chinaglia (1914) who has briefly described the structure of the hairs of the anal tufts of the female moths (and the hairs covering the eggs) in two species, namely, in the Brown Tail, *Euproctis chrysorrhoea* Linn., and in *Lymantria dispar* Linn. In *Euproctis chrysorrhoea* the hairs are of three types, thus : some are long (length 1600–1900 μ ; width 4–6 μ), smooth and with knobbed ends ; others are short (length 100–250 μ ; width $3 \cdot 5$ μ), spinose and with either pointed or tricuspid ends ; and still other hairs are long (length 1000–2000 μ ; width 2–3 μ), fine and with one end knobbed and spiny, the other smooth and pointed. In *Lymantria dispar* Chinaglia stated that the hairs are long and smooth. Regarding the terminal ends in the latter species, one end is shown as pointed in his illustration, the opposite end knobbed ; in abnormal cases, the ends are angularly hooked.

The structure of the egg-masses and the egg-mass hairs in three species of *Lymantria* will now be described in detail.

(*b*) *Lymantria mathura* Moore

(Pl. 1 and Text-figs. 1 and 2)

(*i*) *General*

This species is a serious defoliator of *sál* (*Shorea robusta* Gaerten f.) and a few other species of trees in North India (Beeson, 1941, pp. 638–639). It is distributed all along the Himalayas. A variety of it, *L. mathura* forma *aurora* Butler, is a serious defoliator of oak and apples in Japan (Nishigaya, 1918 ; Blunk, 1925, p. 440) ; the variety is also said to occur in India. For other details of the distribution, etc., of *L. mathura* and allied species, see Hampson (1892), Bryk (1934, p. 151) and Collenette (1938, 1948).

(*ii*) *Egg-masses and eggs* (Pl. 1 and Text-figs. 1 and 2)

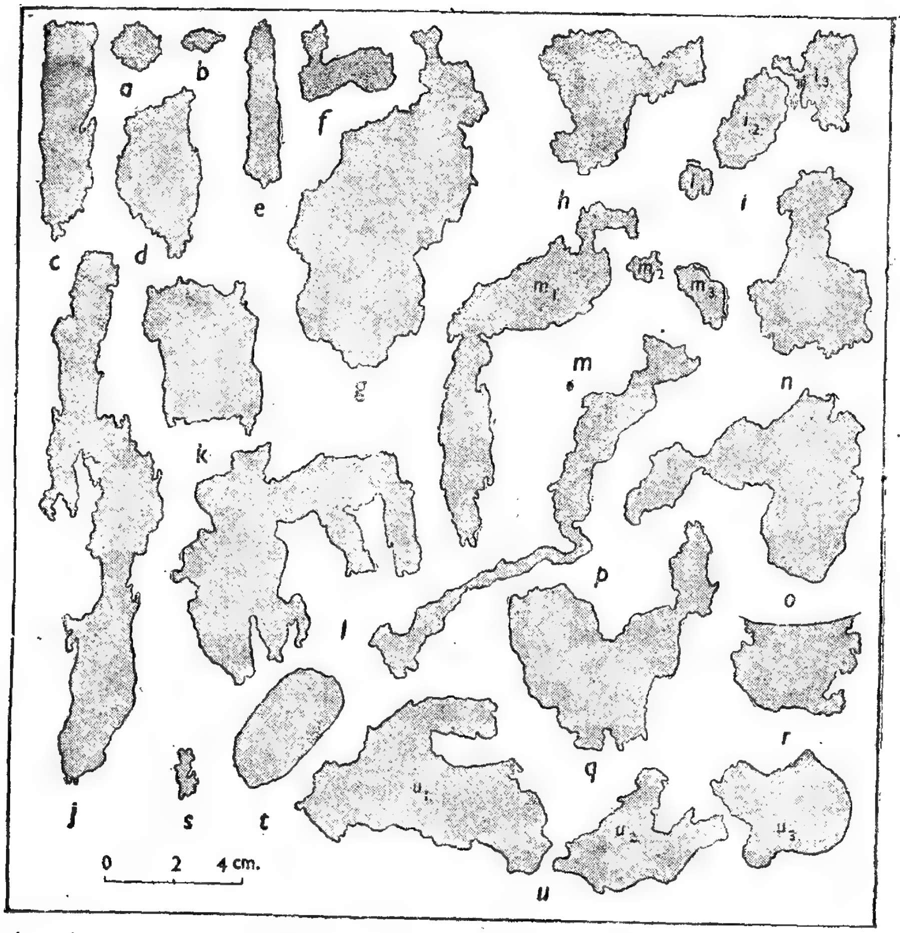
Recently, in September 1953, the population of *L. mathura* underwent a great eruption in numbers, never before recorded, in the Doon Valley and the neighbouring areas in the Western Sub-Himalayas (*vide* Roonwal, 1953, for a preliminary account of the eruption). While in normal years the moth is not conspicuous and lays eggs on the bark of only a few species of trees, during the 1953 eruption it oviposited profusely on the bark (Pl. 1, Figs. 1–5) of nearly 180 species of trees in the Dehra Dun area*. Exceptionally, eggs were laid on leaves, dried fruits (Pl. 1, Figs: 6 and 7) and even on the surfaces of brick walls and metal wire-gauze nettings.

The egg-masses assume a variety of shapes from subovoid to quadrate and semi-linear (Pl. 1 and Text-fig. 1) and vary in size from about 1–15 cm. in length and about $0 \cdot 5$–7 cm. in width. The hair-covering of the egg-masses is pure snow-white. In a transverse section of the egg-mass (Text-fig. 2*a*) it is seen that eggs are laid right on the bark and are arranged in 2 to 3, rarely 4, layers deep. Over the topmost layer of eggs there is a felt-like coating (*hr.*) about one millimetre thick and composed of short, white, silken hairs, completely covering the eggs ; a few similar hairs are also to be found among the eggs.

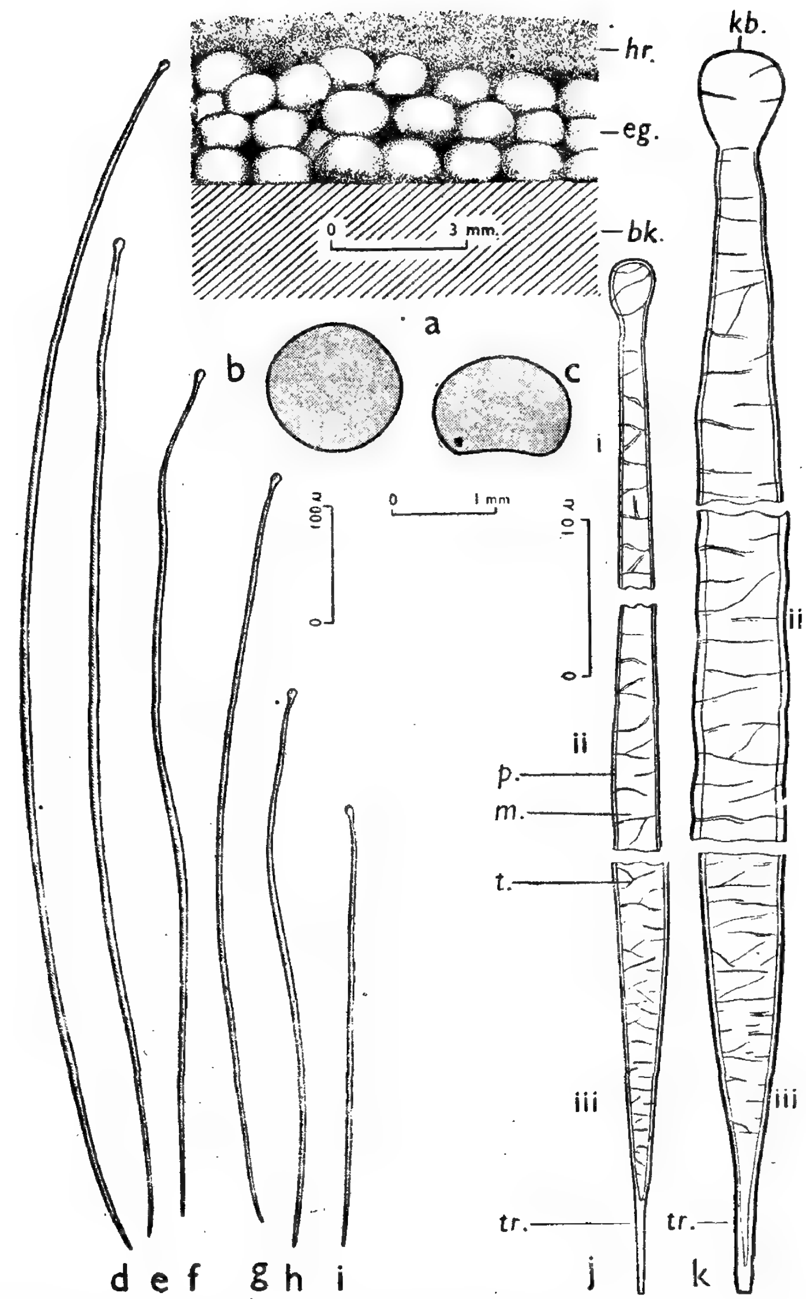
The freshly laid egg (Text-fig. 2 *a–c*) is whitish in colour and is round when seen from above ; the bottom is flattened or slightly caved in so that its "height" is less than its diameter. Ten eggs gave the following measurements :—

Maximum diameter : $1 \cdot 13$–$1 \cdot 19$ mm. (mean $1 \cdot 183$ mm.).
Minimum diameter (height) : $0 \cdot 86$–$0 \cdot 92$ mm. (mean $0 \cdot 902$ mm.).

* Fuller details will be published elsewhere.



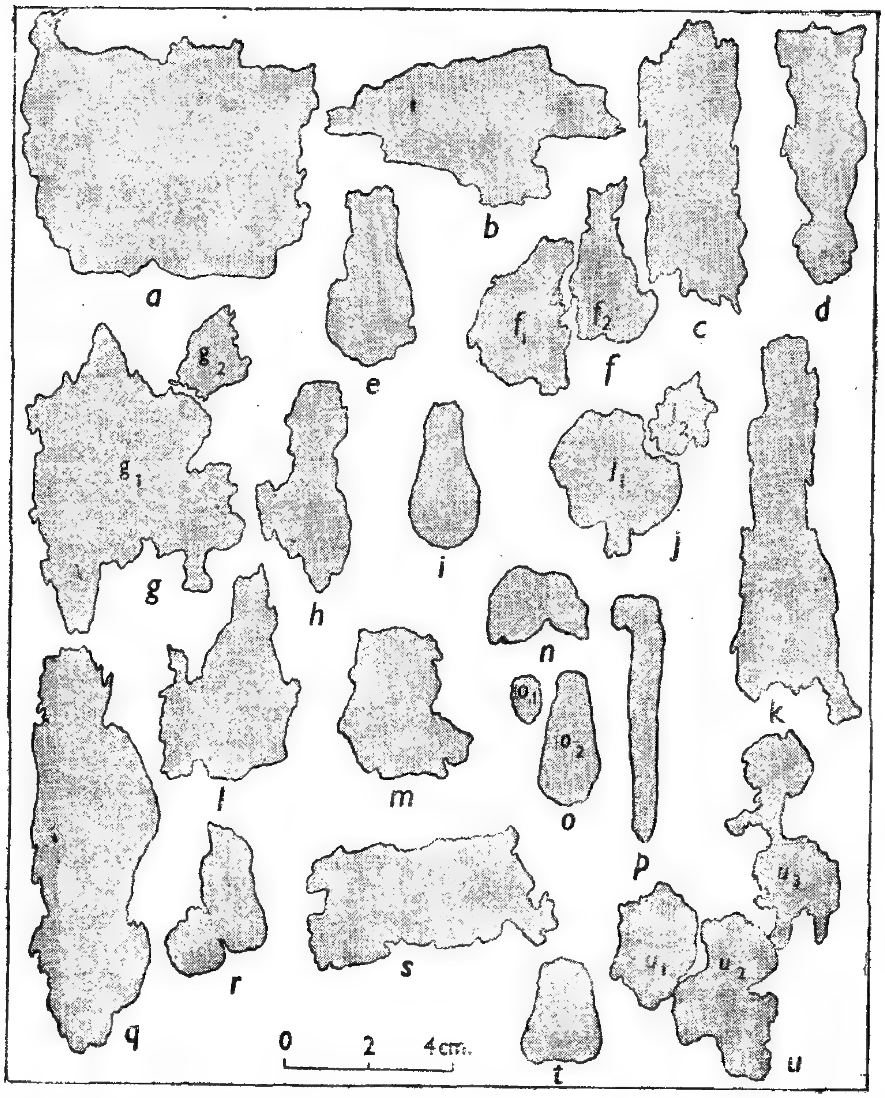
TEXT-FIG. 1 (*a–u*).—*Lymantria mathura* Moore. Outlines of egg-masses, to show various sizes and shapes assumed. Sometimes 2 or 3 adjoining egg-masses, as in m_1, m_2, m_3, etc., are associated with a single female. (From egg-masses laid on trunks of various species of trees in New Forest, Dehra Dun, U.P., India, *ca.* 2,000 feet above sea-level, during the epidemic season September–October, 1953. *M. L. Roonwal Coll.*



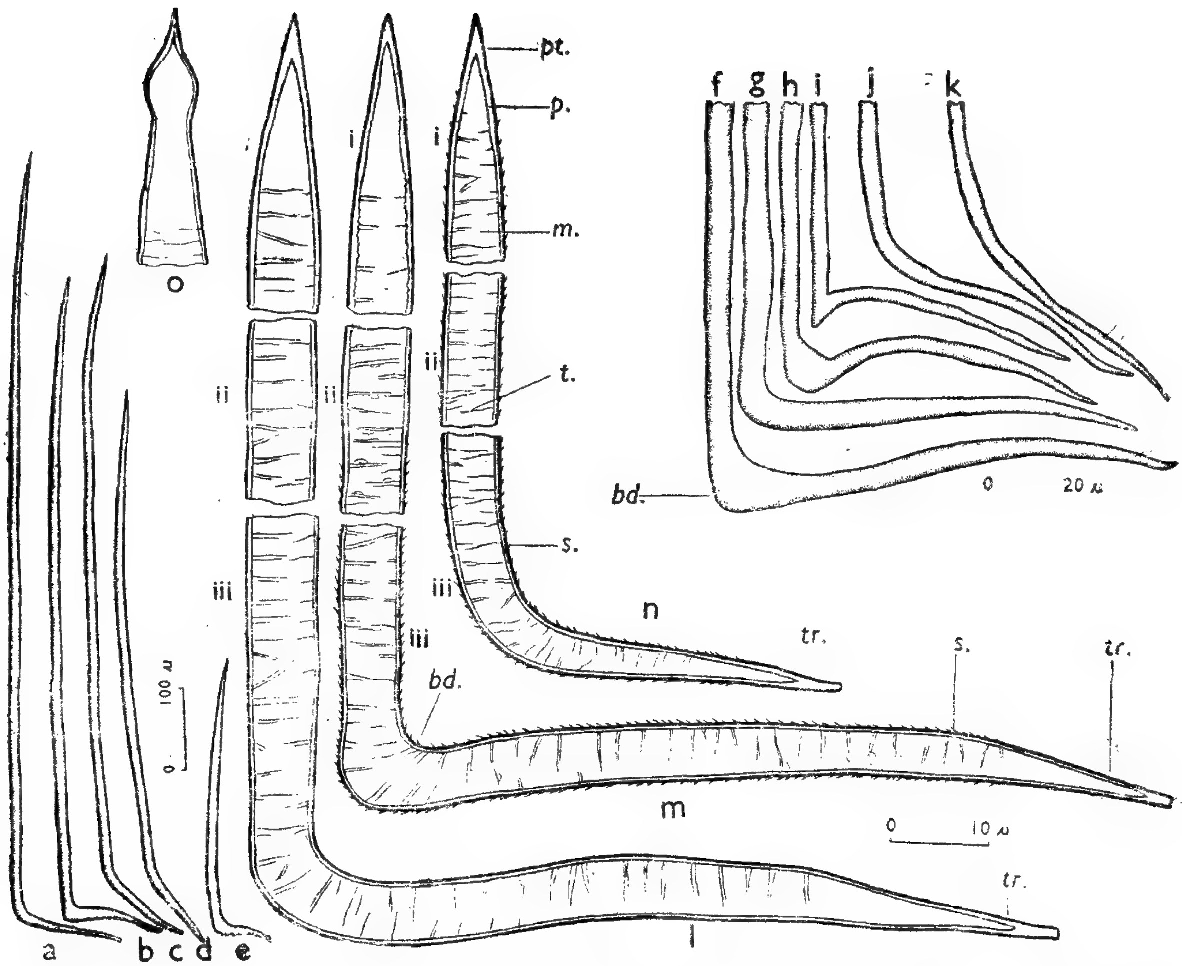
TEXT-FIG. 2 (*a–k*).—*Lymantria mathura* Moore. Structure of the eggs, egg-masses and egg-mass hairs. (From material collected in New Forest, Dehra Dun, U.P., *ca.* 2,000 feet, during epidemic of September–October, 1953. *M. L. Roonwal Coll.*).

(*a*) Transverse section of a portion of an egg-mass, to show the relative arrangement of the eggs and the egg-mass hairs. Diagrammatic. (*b*) An egg, as seen from above. (*c*) Same, in side view. (*d–i*) Individual hairs from the hair coat covering the eggs, to show their general shape and size. (*j*) One of the thinner egg-mass hairs, highly magnified, to show the microscopic structure. The entire hair is not shown; its length is broken up into 3 parts, thus: (i) one end; (ii) middle; and (iii) the other end. (*k*) Same; another but thicker hair shown in sections as in FIG. (*j*).

bd., bend in hair; *bk.*, bark; *eg.*, egg; *hr.*, layer of hairs covering the eggs; *kb.*, swollen, knobbed end of the hair; *m.*, medulla or core; *p.*, pellicle; *pt.*, pointed end of the hair; *t.*, transverse refractile bands across the hair-width; *tr.*, truncated end of the hair; *s.*, spines on the surface of the hairs.



TEXT-FIG. 3 (*a–u*).—*Lymantria obfuscata* Walker. Outlines of egg-masses, to show various sizes and shapes assumed. Sometimes 2 or 3 adjoining egg-masses, as in u_1, u_2, u_3, etc., are associated with a single female. (From Haran Willow Plantation near Gandarbal, about 30 miles west of Srinagar, Kashmir, *ca.* 5,500 feet ; first week November, 1953 ; *M. L. Roonwal Coll.*).



TEXT-FIG. 4 (*a–o*).—*Lymantria obfuscata* Walker. Structure of the egg-mass hairs. (From material collected in first week November, 1953, in Haran Willow Plantation near Gandarbal, 30 miles from Srinagar, Kashmir, *ca.* 5,500 feet; *M. L. Roonwal Coll.*).

(*a–e*) Individual hairs from the hair coat covring the eggs, to show their general shape and size. (*f–k*) End-portions of some egg-mass hairs, similar to those shown in FIGS. (*a–e*), to show the various types of bends. (*l*) An egg-mass hair highly magnified to show the microscopic structure. The entire hair is not shown; its length is broken up into 3 parts, thus: (i) One end; (ii) the middle; and (iii) the other end. Note the absence of spines. (*m*) Same; another hair, similarly broken up. Note the presence of spines on a portion of the hair. (*n*) Same; another hair similarly broken up. Note the presence of spines all over the hair. (*o*) Abnormal end of an egg-mass hair, to show the swollen pointed end.

Lettering as in TEXT-FIG. 2.

(*iii*) *Egg-mass hairs* (Text-fig. 2)

The egg-mass hairs are long and fine (Text-fig. 2 *d–i*) and measure about 800–1200 μ (mean of eleven hairs 960 μ) in length and about $3 \cdot 1$–$6 \cdot 2$ μ (mean of ten hairs $5 \cdot 1$ μ) in maximum diameter. As regards width, there appear to be two categories of hairs, *viz.*, with maximum diameters of (*i*) *ca.* $3 \cdot 1$–$3 \cdot 5$ μ ; and (*ii*) *ca.* $5 \cdot 0$–$6 \cdot 2$ μ ; a few intermediates do occur but are not common. The hairs look pure snow-white in incident light and practically colourless in transmitted light. They gradually taper towards the two extremities one of which ends in a swollen knob-like head (*kb.*) while the other extremity, which is comparatively more elongate, is bluntly truncated (*tr.*). Each hair has an outer covering of refractile, pale yellow pellicle (*p.*) and a central thick core or medulla (*m.*) which is colourless. In a flat mount of the hair on a glass slide the medulla appears to be traversed by thin, transverse and oblique bands (*t.*) of refractile material which probably represent the scaliness of the pellicle. The outer surface of the pellicle is otherwise smooth and is not armed with spines (*cf.* other species below).

(*c*) *Lymantria obfuscata* Walker

(Text-figs. 3 and 4)

(*i*) *Egg-masses* (Text-fig. 3)

This species is a serious defoliator of willows in the Kashmir Valley. The egg-masses are generally subovoid in outline but also assume a variety of other shapes, the size varying from about 1–10 cm. in length to $0 \cdot 5$–6 cm. in width. Their hair-covering is golden brown. The shape and arrangement of the eggs in the egg-mass is similar to that described above in *Lymantria mathura*.

(*ii*) *Egg-mass hairs* (Text-fig. 4)

The felt-like covering of hairs over the egg-masses presents a golden brown appearance, somewhat darkening with age. The relative arrangement of the eggs and the hairs over each egg-mass is as in *Lymantria mathura*.

Each hair is comparatively short and stout (Text-fig. 4 *a–e*) and measures about 350–1010 μ (mean of ten hairs 720 μ) in length and 5–8 μ (mean of ten hairs $6 \cdot 8$ μ) in maximum diameter. The hair looks golden brown to pale yellowish brown in incident light and yellowish in transmitted light. Towards the two extremities the hair slopes gradually. One of these extremities is sharply pointed (*pt.*), while the opposite one, which is comparatively more prolonged, is bluntly truncated (*tr.*). In an abnormal case the pointed end showed a subapical globular swelling (Text-fig. 4 *o*) ; in another abnormal case the truncated end was weakly knobbed. Towards the truncated end the hairs generally show a sharp characteristic bend (*bd.*), the bent extremity measuring about 69–92 μ (mean of ten hairs 82 μ) in length. While generally the bend is sharp and there is often a slight protruberance at the outer corner of the bend (Text-fig. 4 *f–k*), in some cases the bend is gradual (Text-fig. 4 *d, j*), and in rare cases there is hardly any bend at all (Text-fig. 4 *k*). In the possession of spiny armature on the surface of the pellicle there is considerable variation. Some hairs (Text-fig. 4 *l*) have a smooth pellicle throughout their length, while others (Text-fig. 4 *n*) are clothed almost throughout the length with delicate spines (*s.*), all of which slope towards the pointed end of the hair. In still other cases (Text-fig. 4 *m*) the portion of the hair towards the pointed end is smooth, while the other half is armed with spines. In an unstained mount the hairs are seen to possess a highly refractile outer pellicle (*p.*) and a colourless medulla (*m.*). Except near the extreme tips, the latter appears to be traversed, as in *L. mathura*, by an irregular row of transverse and oblique refractile bands (*t.*) which, however, are thicker than in *L. mathura*.

(*d*) *Lymantria ?dispar* Linnaeus

(Text-fig. 5)

(*i*) *General*

This species, which is the notorious Gypsy Moth of Europe and North America, is a serious pest of forest and fruit trees in the palaearetic and the nearactic regions. From Europe it was introduced into the United States of America over 60 years ago, *vide* Howard and Fiske (1911), Blunck (1925) and Escherich (1931).

(*ii*) *Egg-masses* (Text-fig. 5 *a*)

Howard and Fiske (1911, p. 152 and Pl. 6) gave a coloured illustration of the egg-mass of this moth, while Berlese (1925, p. 517, Fig. 545) illustrated it in black and white. In both the illustrations the egg-mass is shown as oval in outline.

One egg-mass, apparently from Central Europe (Germany ?) and labelled as follows, is present in the Entomological Collection of the Forest Research Institute, Dehra Dun, and was studied :—

"*Lymantria dispar* L. GYP egg-cluster. Müggel See . . . . 22nd June 12".

This egg-mass is laid on a piece of bark, is elongate-oval in shape and measures about $1 \cdot 5 \times 3 \cdot 3$ cm. The hair-covering of the egg-mass is dark brown, almost earth-coloured, and is very much darker than in *L. obfuscata.*

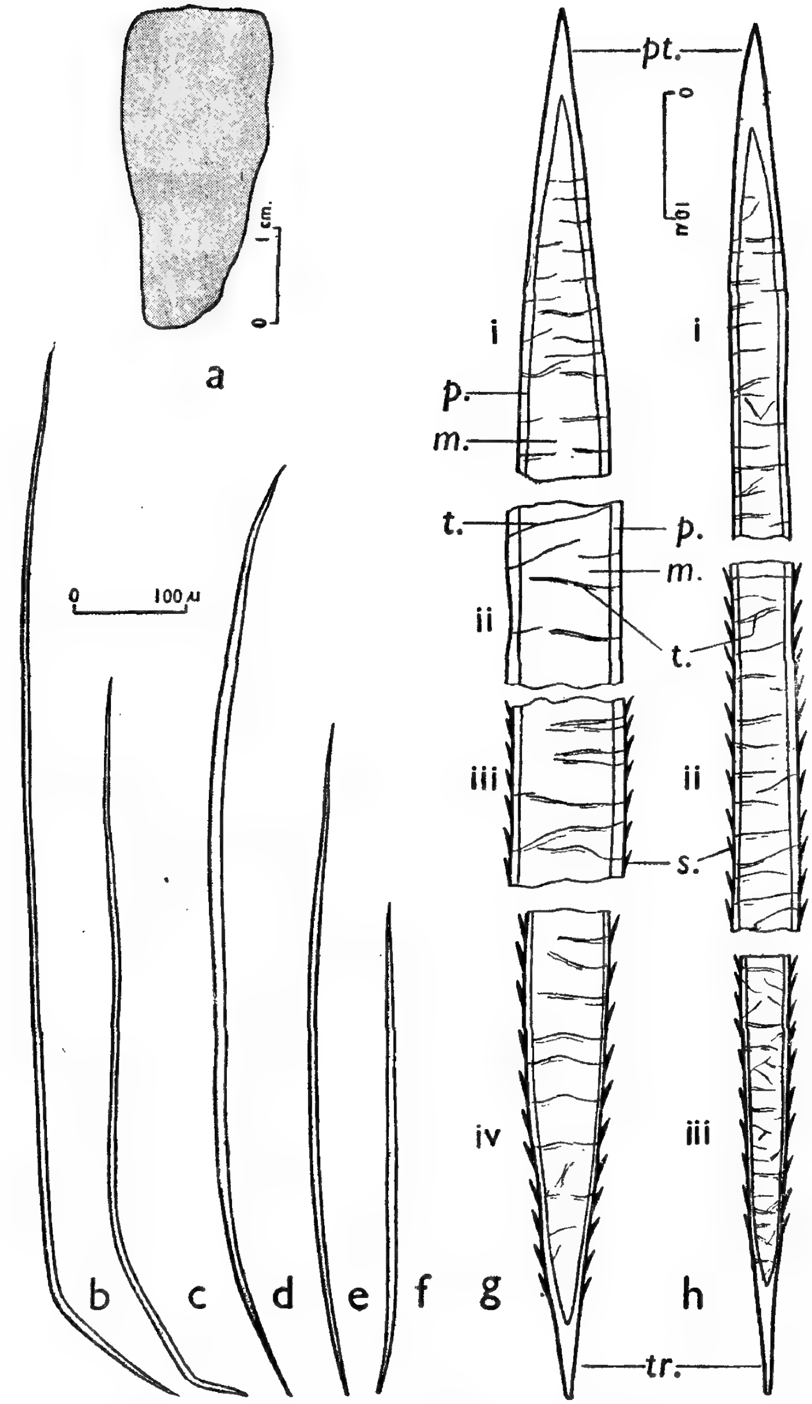
(*iii*) *Egg-mass hairs* (Text-figs. 5 *b–h*)

The hairs are short and stout and usually curve smoothly and gently ; occasionally they have up to 3 or 4 rather sharp bends. They measure about 460–880 μ in length (mean of ten hairs 685 μ) and have a maximum diamter of about $6 \cdot 2$–$9 \cdot 3$ μ (mean of ten hairs $8 \cdot 23$ μ). The hairs look dark brown in incident light and dirty yellow in transmitted light. As in *L. obfuscata*, each hair slopes towards the two extremities, ending at one end in a sharp point (*pt.*), while the other end is bluntly truncated (*tr.*). The portion of the hair towards the truncated end is armed with a covering of sharp prominent spines (*s.*) which slope towards the truncated end ; the remainder of the hair is smooth. As in *L. mathura*, each hair has a highly refractile yellowish outer pellicle (*p.*) and a colourless medulla (*m.*) which is traversed by thin, irregular, transverse and oblique refractile bands (*t.*).

It may be stated that in Chinaglia's (1914) illustration of the hairs of *L. dispar* one of the ends is shown as knobbed and the other pointed ; abnormally, according to the same author, the ends are angularly hooked like a part of a ship's anchor. No further details are given by Chinaglia.

(*e*) *Discussion and Conclusions*

A study of the microscopic structure of the hairs covering the egg-masses of three species of *Lymantria* has shown that each species has its own characteristic structure and that it is possible to distinguish the egg-masses of the different species by an examination of these hairs. These differences lie principally in the following characters :—(*i*) The nature of the two extremities – whether pointed, truncated, knobbed, and so on. (*ii*) The presence or absence of a bend or bends in the length of the hairs. (*iii*) The presence or absence of the spiny armature on the outer surface of the hairs, and the character of the armature. (*iv*) The size, *i e.*, length and width, of the hairs. (*v*) The colour of the hairs.



TEXT-FIG. 5 (*a–h*).—*Lymantria ?dispar* Linnaeus. Egg-mass and the structure of the egg-mass hairs. [From an egg-mass present in Entomological Collection, Forest Research Institute, Dehra Dun, apparantly collected from Central Europe (Germany ?) and with the following label: "Lymantria *dispar* L. GYP egg-cluster. Müggel See . . . . 22 June 12.]".

(*a*) Outline of an egg-mass. (*b–f*) Individual hairs from the hair-coat covering the eggs, to show their general shape and size. (*g*) An egg-mass hair, highly magnified to show the microscopic structure. The entire hair is not shown; its length is broken up into 4 parts, thus: (i) one end; (ii) and (iii) middle portions; and (iv) the other end. (*h*) Same; a thinner hair, shown broken up into 3 parts.

Lettering as in TEXT-FIG. 2.

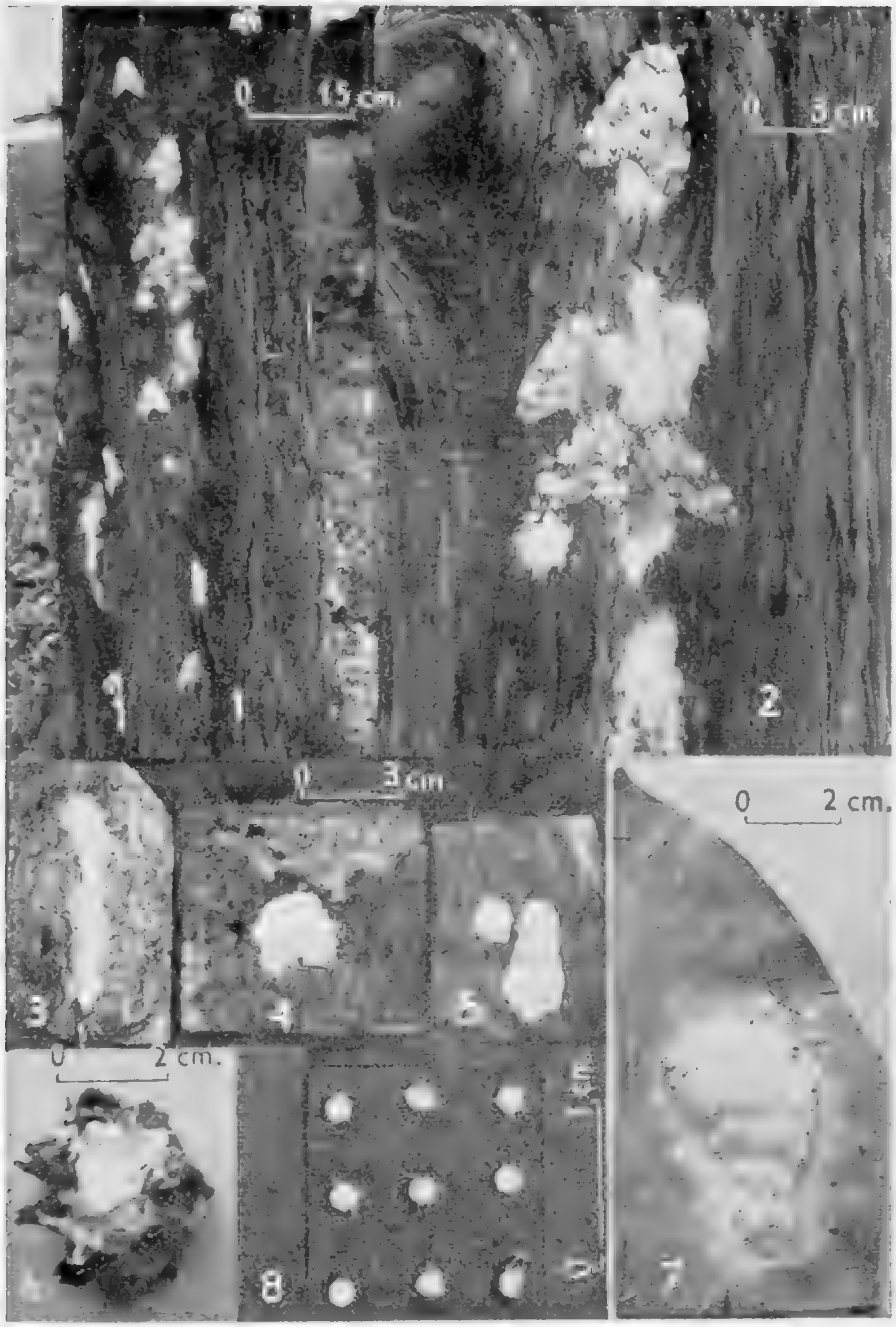


PLATE 1

Female moths, eggs-masses and eggs of *Lymantria mathura* Moore.

FIG. 1.—Female moths in natural posture and the associated egg-masses (white patches) on the trunk of a juniper, *Juniperus procera* Hochst., in New Forest near Dehra Dun (Uttar Pradesh, India), altitude *ca.* 2,000 feet above sea-leavel. Photo on 23rd October 1953. September–October 1953 was an unusual epidemic season, and extensive oviposition took place in the Doon Valley and the neighbouring areas in the Western Sub-Himalayas.

FIG. 2.—Portion of the same as in FIG. 1, but enlarged. Note the whitish egg-masses adjoining the females.

FIGS. 3, 4 and 5.—Egg-masses on trunks of various species of trees. Same history as in FIG. 1.

FIGS. 6 and 7.—Egg-masses abnormally laid on fruit (FIG. 6) and leaf (FIG. 7) of *Duabanga sonneratoides* Ham., in New Forest, Dehra Dun. History as in FIG. 1. Note the eggs in FIG. 7.

FIG. 8.—Nine eggs taken from an egg-mass. Enlarged. The eggs are spherical. Note the minute hairs sticking to the eggs.

In addition to the microscopic structure of the hairs, the size and shape of the egg-masses and the colour of the hairs covering them also provide useful differentiating characters. The differences occurring among the three species discussed above have been summarized in Table 1 and in the key given below :—

TABLE 1.—*Comparison of the egg-masses and egg-mass hairs of three species of the genus* Lymantria (*family Lymantriidae*).

Lymantria mathura Moore	*Lymantria obfuscata* Walker	*Lymantria ?dispar* Linnaeus
I. EGG-MASS	I. EGG-MASS	I. EGG-MASS (Only one examined)
1. Shape various.	1. Shape usually subovoid; but varies considerably.	1. Shape ovoid.
2. Size large. Length *ca.* 1–15 cm.; width *ca.* 0·5–7 cm.	2. Size smaller. Length *ca.* 1–10 cm.; width *ca.* 0·5–6 cm.	2. Size small. Length 1·5 cm.; width 3·3 cm.
3. Hair-coat pure snow-white.	3. Hair-coat golden brown to pale yellow brown.	3. Hair-coat dark brown or earth coloured (in specimen several years old).
II. STRUCTURE OF EGG-MASS HAIRS	II. STRUCTURE OF EGG-MASS HAIRS	II. STRUCTURE OF EGG-MASS HAIRS
1. Hairs long and fine, with a gentle, smooth curve.	1. Hairs short and stout, with a characteristic sharp bend near one end.	1. Hairs short and stout. Mostly with a gentle curve, but occasionally with up to 3 or 4 rather sharp bends.
2. Length *ca.* 800–1200 μ (mean 960 μ); maximum width *ca.* 3·1–6·2 μ (mean 5·0 μ).	2. Length *ca.* 350–1010 μ (mean 720 μ); maximum width *ca.* 5·0–8·0 μ (mean 6·8 μ).	2. Length *ca.* 460–880 μ (mean 685 μ); maximum width *ca.* 6·2–9·3 μ (mean 8·23 μ).
3. White in incident light. Practically colourless in transmitted light.	3. Golden brown to pale yellowish brown in incident light. Yellowish in transmitted light.	3. Dark brown in incident light Dirty yellow in transmitted light.
4. One extremity of hair roundly swollen and knob-like; the opposite extremity comparatively more elongate and bluntly truncated.	4. One extremity of hair sharply pointed; the opposite extremity comparatively more elongate and bluntly truncated.	4. One extremity of hair sharply pointed; the opposite extremity comparatively more elongate and bluntly truncated.
5. Outer surface of hair smooth and not armed with spines.	5. Outer surface of hair either smooth throughout or armed with weak spines (sloping towards the truncated end) either throughout or for a portion (usually the truncated half) of its length.	5. Outer surface of hair smooth and unarmed towards the pointed half; armed with strong spines towards the truncated half.

Key for the differentiation of the egg-mass hairs of species of Lymantria

1 (2). One of the two hair extremities swollen and knob-like, the other bluntly truncated. Hairs long and fine (length 800–1200 μ; maximum diameter 3·1–6·2 μ). Outer surface smooth. .... *L. mathura* Moore.

2 (3). Hair extremities not swollen and knob-like; one extremity sharply pointed, the other bluntly truncated. Hairs short and stout (length 350–1010 μ; maximum diameter 5·0–9·3 μ. Wholly or partly armed with spines.

3 (4). Hairs sharply bent at one end. Outer surface either smooth, or partly or wholly covered with weak spines. Length 350–1010 μ; maximum diameter 5–8 μ .... *L. obfuscata* Wlk.

4. Hairs not sharply bent at one end. Outer surface armed with strong spines towards the truncated end, and unarmed elsewhere. Length 460–880 μ; maximum diameter 6·2–9·3 μ .... *L. ?dispar* Linn.

III. SUMMARY

1. The gross structure of the egg-masses and the microscopic structure of the hairs covering them have been studied in three species of the genus *Lymantria*.

2. The eggs are laid in masses on the surface of the bark or leaves and are covered over with a felt-like layer of hairs which presents a characteristic appearance. The eggs are arranged up to 3 or 4 layers deep. Each egg is rounded, with a flattened lower surface.

3. The microscopic structure of the egg-mass hairs in the three species is characterised as follows :—

(*a*) *Lymantria mathura* Moore—One extremity swollen and knob-like, the other bluntly truncated. Hairs long and fine. Length 800–1200 μ ; maximum diameter $3 \cdot 1$–$6 \cdot 2$ μ. Outer surface smooth.

(*b*) *Lymantria obfuscata* Walker—One extremity sharply pointed, the other bluntly truncated. Hairs short and stout and with a characteristic bend near the truncated end. Length 350–1010 μ ; maximum diameter 5–8 μ. Outer surface either smooth or partly or wholly armed with weak spines which slope towards the truncated end.

(*c*) *Lymantria ?dispar* Linnaeus—Extremities as in *L. obfuscata*. Hairs short and stout. Length 660–880 μ ; maximum diameter $6 \cdot 2$–$9 \cdot 3$ μ. Outer surface armed with strong spines towards the truncated half, naked elsewhere ; the spines sloping towards the truncated end.

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A PRELIMINARY NOTE ON THE PREPARATION, BY A SIMPLE PROCESS, OF COPPER AND ZINC PRESERVATIVES FROM CHIR RESIN

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Of the three types of preservatives, viz., oil type, water soluble type and organic solvent type, the last consists of mainly chlorinated organic compounds like Pentachlorophenol, Hexachlorobenzene, etc., and copper and zinc salts or soaps of organic acids like Naphthenic acid, Stearic acid, Abietic acid, etc. In the last group the toxic property of the preservative is derived from the cupric and zinc ions. These are by the by also responsible for the toxicity of inorganic preservatives like copper sulphate and zinc chloride, well known in the field of wood preservation. The advantages of these copper and zinc soaps, over their corresponding inorganic salts are their high resistance (i) to leaching by water (ii) to corrosion on mild steel and iron and (iii) to chemical action or changes during treatment operations of wood and during the service life of treated timber. These preservatives are also comparatively less hazardous to the health of workers handling them. Again, compared with the oil type of preservatives like creosote, these have little or no objectionable smell, leave a clean surface on the treated timber which can either be painted or varnished. This is because the solvents generally used to dilute these preservatives belong to petroleum products of high volatility. However, these preservatives have not found such general applicability as the inorganic salts and creosote in the field of commercial wood preservation because of their relatively high cost. They are, therefore, generally recommended for brush treatment of slightly durable species of timber used in the furniture, tool handle, packing case, etc., industries. For protection of cloth, against decay, these are perhaps the best preservatives available.

There are several proprietary preservatives like Cuprinol, Hardiproof, Almatox, etc., in which naphthenic acid or stearic acid is mainly used as the basic organic acid in the preparation of copper and zinc soaps. Generally naphthenic acid is used and, at present, it has to be imported. Therefore, an attempt to prepare these preservatives was made by the senior author from indigenous sources, during the last war when there was a very acute shortage of all wood preservatives. Two lines on which the problem was approached consisted of (i) utilization of indigenous materials such as vegetable oils unfit for human consumption and chir resin and (ii) elimination of the intermediary soap preparation using costly alkalies – Sodium or Potassium hydroxides and final reaction with copper sulphate.

In 1942, Copper and zinc preservatives were thus prepared from Mohwa oil by subjecting it to thermal cracking and direct reaction of the liberated free acids from the glycerides (mainly stearic acid) and copper and zinc metals in the form of fine powder or turnings. The preservative (Vecu) so prepared, diluted with fuel oil, was impregnated into various species of timbers of low natural durability. The latest graveyard inspection indicates that while a 70% dilution gives fairly satisfactory results, a 50% dilution would be more suitable for treatment of timber to be used in the open and in contact with the ground. The value of these results lay in the utilization of hitherto commercially unimportant vegetable oils, particularly those that are now destroyed because of excess rancidity developed.

Side by side with the above experiments, chir resin was also selected for investigation because it contains a large proportion of free abietic acid. After careful preliminary investigations, it was noticed that by dissolving this mass of thick substance in kerosene, copper and zinc abietates could be formed by heating to a temperature of 60° to 70°C. in presence of finely suspended copper and zinc metals. These experiments did not prove a success because

of low metallic contents of the preservative, decomposition or transformation into unsuitable compounds in kerosene solutions on standing, particularly on exposure to sunlight. The problem, therefore, required further careful investigation.

In the experiments now undertaken during the last 18 months, crude benzene was found to be more suitable as a solvent for the resin than kerosene, mentioned above. Copper and zinc preservatives were prepared by using the metals in the form of foils, turnings, fine powder and as oxides. Heating was carried out by water or steam baths. To prevent the loss of the solvent by volatalization, water cooled condensers were employed. A suitable plant, for the preparation of the preservative on a cottage industry basis, was also developed using a copper vessel of 5 gallon capacity. A stirrer worked by an electric motor or by manual labour and containing hollow perforated wooden blades, in which the metal substances could be carefully packed, was found to hasten the reaction.

At present preservatives containing 2·8 and 6 per cent copper and zinc metal respectively have been prepared from chir resin by the above method.

The graveyard reports, on experiments conducted in 1930 using copper resinate prepared by the costly process using sodium and potassium hydroxides, *vide* table No. 1, are quite encouraging. Unfortunately the absorptions obtained have not been recorded, but they could not have been very heavy, because of the employment of the hot and cold or open tank process of treatment.

Data on exposure tests, in the laboratory and in the field, indicate that a retention[1] of 8 lbs./c. ft. of copper naphthenate solution in petroleum oil containing 0·5% copper metal or 0·5 lbs. zinc chloride[2]/c. ft. are adequate for protection of timber under fairly severe exposure conditions. This means that a retention of a preservative containing 0·04 lb./c. ft. copper metal or 0·2 lb./c. ft. of zinc gives adequate protection to timber. Therefore, the copper and zinc abietates, now prepared containing roughly 3 and 6% copper and zinc respectively, can safely be diluted to six times and to two times respectively. As mentioned earlier, these preservatives are especially intended for treatment of timbers for use under less severe conditions of deterioration and, therefore, such heavy absorptions as mentioned above are not necessary. There is also the possibility of increasing the metallic contents, as a result of further work which is being carried on. An additional and important feature of this preservative, using crude resin containing turpentine, is its utility as a varnish. Very fine finishes have been obtained on furniture timbers. Again, experience so far gained shows that the defects, encountered earlier, while using kerosene as a solvent, are eliminated by the use of benzene. Benzene, though comparatively costly, is more suitable than kerosene, because benzene evaporates off very easily from the treated timber surface unlike kerosene.

The economic cost of these preservatives is given in table No. 2. For purposes of comparison, the present market rates of similar products, but not containing turpentine, are also given. These show the economic potentialities of the copper and zinc preservatives, prepared from chir resin by the simple process described in this paper, and how well a new cottage industry in the preparation of these preservatives can be established in the country.

A detailed account of all these results including further work now in progress on the subject, will be published in due course.

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TABLE 1.—*Summary of the Condition specimens*

Species of timber	No. and size of specimens	Preservative used	Treatment process	Absorption lbs./cu. ft.		
				Max.	Min.	Average
Shorea robusta (sapling) ..	12[b]	Vecu (Copper preservative : Earth oil) 80 : 70	Pressure treated	15·6	8·9	12·5
Do.	12[b]	Do.	Open tank-heating at 80°C. for 4 hrs. Cooling 16 hrs.	14·8	8·6	11·9
Do.	2[b]	Control	..	..	..	..
Do.	11[b]	Vecu (Copper preservative : Earth oil) 20 : 80	Pressure treated	15·6	7·8	10·8
Do.	12[b]	Do.	Open tank-heating at 80°C. for 4 hrs. Cooling 16 hrs.	15·6	8·0	12·3
Do.	2[b]	Control	..	..	..	..
Do.	11[b]	Vecu (Copper preservative : Earth oil) 10 : 90	Pressure treated	13·5	6·4	9·7
Do.	12[b]	Do.	Open tank-heating at 80°C. for 4 hrs. Cooling 16 hrs.	13·4	7·8	9·7
Do.	2[b]	Control	..	..	..	..
Pinus longifolia (sapwood)	6[a]	Vecu : Earth oil 30 : 70	Open tank-heating at 80°C. for ½ hr. Cooling for ½ hr.	23·3	5·1	14·8
Bombax malabaricum ..	6[a]	Do.	Do.	7·6	5·1	6·5
Pinus longifolia (sapwood)	6[a]	Vecu : Earth oil 20 : 80	Do.	22·8	13·8	17·7
Bombax malabaricum ..	6[a]	Do.	Do.	7·3	5·9	6·5
Pinus longifolia (sapwood)	6[a]	Vecu : Earth oil 10 : 90	Do.	24·8	8·7	17·5
Bombax malabaricum ..	6[a]	Do.	Do.	7·9	5·9	6·5
Pinus longifolia (sapwood)	6[a]	Control	..	..	..	..
Bombax malabaricum ..	6[a]	Control	..	..	..	..
Bambusa arundenacea ..	6	Vecu : Earth oil 10 : 90	Open tank-heating at 80°C. for ½ hr. and cooling for 22 hrs.	7·8	4·2	5·1
Dendrocalamus strictus ..	6	Do.	Do.	5·4	3·3	4·3
Bambusa arundenacea ..	6	Do.	Pressure treated	7·3	4·2	5·0
Dendrocalamus strictus ..	6	Do.	Do.	5·5	3·3	4·6
Bambusa arundenacea ..	6	Control	..	..	..	..
Dendrocalamus strictus ..	6	Control	..	..	..	..
Pinus longifolia (sapwood)	6[a]	Almatox	Pressure treated (lowry)	28·1	12·4	20·0
Bombax malabaricum ..	6[a]	Do.	0–60 lbs./sq. in. for 1 hr.	19·7	6·8	12·5
Pinus longifolia (sapwood)	6[a]	Do.	0–25 lbs./sq. in. for 1 hr.	18·0	7·9	12·2

laid down in the Graveyard at New Forest

Date of laying	Date of last inspection	Summary of the condition of the specimens at last inspection					Average life	
		Number sound	Number slightly attacked	Number moderately attacked	Number badly attacked	Number destroyed	Years	months
29-7-43	11-2-52	..	..	..	..	12	7	9
,,	,,	..	..	..	..	12	7	2
,,	,,	..	..	..	..	2	1	8
,,	,,	..	..	..	..	11	4	3
,,	,,	..	..	..	..	12	6	10
,,	,,	..	..	..	..	2	1	0
,,	,,	..	..	..	..	11	5	1
,,	,,	..	..	..	..	12	3	4
,,	,,	..	..	..	..	2	1	0
17-8-43	20-1-54	2	4	..	..	..	..	..
,,	,,	..	..	1	1	4	..	..
,,	,,	4	1	..	..	1	..	..
,,	,,	..	..	2	1	3	..	..
,,	,,	3	2	..	..	1	..	..
,,	,,	..	..	1	1	4	..	..
,,	,,	..	..	..	..	6	1	8
,,	,,	..	..	..	..	6	1	..
18-8-43	9-1-53	..	..	..	..	6	1	9
,,	,,	..	..	..	..	6	4	..
,,	,,	..	..	..	..	6	1	4
,,	,,	..	..	..	..	6	5	2
,,	,,	..	..	..	..	6	..	10
,,	,,	..	..	..	..	6	1	2
4-8-48	20-1-54	4	2	..	..	..	..	..
,,	,,	4	2	..	..	..	..	..
,,	,,	5	1	..	..	..	..	..

(contd.)

TABLE 1.—*Summary of the Condition specimens*

Species of timber	No. and size of speci-mens	Preservative used	Treatment process	Absorption lbs./cu. ft.		
				Max.	Min.	Aver-age
Bombax malabaricum ..	6[a]	Almatox	0–25 lbs./sq. in. for 1 hr.	12·9	7·9	10·6
Pinus longifolia (sapwood)	6[a]	Control	..	..	..	..
Bombax malabaricum ..	6[a]	Control	..	..	..	..
Pinus longifolia (sapwood)	6[a]	Hardiproof	Pressure treated	26·4	11·3	16·1
Bombax malabaricum ..	6[a]	Do.	Do.	10·1	6·2	8·1
Pinus longifolia (sapwood)	6[a]	Control	..	..	..	..
Bombax malabaricum ..	6[a]	Control	..	..	..	..
Shorea robusta (sapling) ..	12[b]	Hardiproof	Pressure treated (lowry)	14·3	5·2	8·9
Do.	1[b]	Control	..	..	..	..
Pinus longifolia ..	1[a]	Cuprinol (Green)	Immersed for 24 hrs.	..	..	1·4
Do.	1[a]	Control	..	..	..	..
Adina cordifolia ..	1[a]	Cuprinol (Green)	Immersed for 24 hrs.	..	..	5·3
Do.	1[a]	Control	..	..	..	..
Picea morinda ..	1[a]	Cuprinol (Green)	Immersed for 24 hrs.	..	..	1·1
Do.	1[a]	Control	..	..	..	..
Abies pindrow ..	1[a]	Cuprinol (Green)	Immersed for 24 hrs.	..	..	1·7
Do.	1[a]	Control	..	..	..	..
Schleichera trijuga ..	1[a]	Cuprinol (Green)	Immersed for 24 hrs.	..	..	3·1
Do.	1[a]	Control	..	..	..	..
Bombax malabaricum ..	1[a]	Cuprinol (Green)	Immersed for 24 hrs.	..	..	5·9
Do.	1[a]	Control	..	..	..	..
Terminalia tomentosa ..	1[a]	Cuprinol (Green)	Immersed for 24 hrs.	..	..	1·1
Do.	1[a]	Control	..	..	..	..
Anogeissus latifolia ..	1[a]	Cuprinol (Green)	Immersed for 24 hrs.	..	..	4·2
Do.	1[a]	Control	..	..	..	..
Lannea grandis ..	1[a]	Cuprinol (Green)	Immersed for 24 hrs.	..	..	4·5
Do.	1[a]	Control	..	..	..	..
Pinus longifolia ..	1[a]	Cuprinol (Super)	Immersed for 24 hrs.	..	..	2·2
Do.	1[a]	Control	..	..	..	..
Picea morinda ..	1[a]	Cuprinol (Super)	Immersed for 24 hrs.	..	..	3·1

laid down in the Graveyard at New Forest

Date of laying	Date of last inspection	Summary of the condition of the specimens at last inspection					Average life	
		Number sound	Number slightly attacked	Number moderately attacked	Number badly attacked	Number destroyed	Years	months
4-8-48	20-1-54	4	2	..	..	..	..	..
,,	,,	..	..	..	..	6	1	4
,,	,,	..	..	..	..	6	..	8
28-11-47	20-1-54	5	1	..	..	..	..	..
,,	,,	6	..	..	..	..	..	..
,,	,,	..	..	..	..	6	2	1
,,	,,	..	..	..	..	6	1	1
27-11-47	6-2-54	4	3	3	..	2	..	..
,,	,,	..	..	..	..	1	1	5
4-5-35	19-1-54	..	..	..	..	1	9	7
,,	,,	..	..	..	..	1	4	8
,,	,,	..	1	..	..	..	..	..
,,	,,	..	..	..	..	1	3	7
,,	,,	..	..	..	..	1	9	7
,,	,,	..	..	..	..	1	..	7
,,	,,	..	..	..	..	1	7	7
,,	,,	..	..	..	..	1	..	7
,,	,,	..	..	..	..	1	17	8
,,	,,	..	..	..	..	1	3	7
,,	,,	..	..	..	..	1	17	8
,,	,,	..	..	..	..	1	..	7
,,	,,	..	..	..	..	1	8	..
,,	,,	..	..	..	..	1	4	..
,,	,,	..	..	..	..	1	9	7
,,	,,	..	..	..	..	1	1	11
,,	,,	..	..	..	..	1	6	7
,,	,,	..	..	..	..	1	..	7
4-5-35	21-2-52	..	..	..	..	1	9	7
,,	,,	..	..	..	..	1	4	8
,,	,,	..	..	..	..	1	4	8

(*contd.*)

TABLE 1.—*Summary of the Condition specimens*

Species of timber	No. and size of speci-mens	Preservative used	Treatment process	Absorption lbs./cu. ft.		
				Max.	Min.	Aver-age
Picea morinda ..	1ᵃ	Control	..	..	..	..
Abies pindrow ..	1ᵃ	Cuprinol (Super)	Immersed for 24 hrs.	..	..	2·8
Do.	1ᵃ	Control	..	..	..	..
Schleichora trijuga ..	1ᵃ	Cuprinol (Super)	Immersed for 24 hrs.	..	..	3·4
Do.	1ᵃ	Control	..	..	..	..
Bombax malabaricum ..	1ᵃ	Cuprinol (Super)	Immersed for 24 hrs.	..	..	12·6
Do.	1ᵃ	Control	..	..	..	..
Terminalia tomentosa ..	1ᵃ	Cuprinol (Super)	Immersed for 24 hrs.	..	..	1·7
Do.	1ᵃ	Control	..	..	..	..
Anogeisus latifolia ..	1ᵃ	Cuprinol (Super)	Immersed for 24 hrs.	..	..	5·6
Do.	1ᵃ	Control	..	..	..	..
Lannea grandis ..	1ᵃ	Cuprinol (Super)	Immersed for 24 hrs.	..	..	9·0
Do.	1ᵃ	Control	..	..	..	..
Pinus longifolia ..	1ᵃ	Copper Resinate 2% (in earth oil)	Open tank-heating up to 100°C. for 2 hrs. and cooling for 15 hrs.	..	..	..
Pinus excelsa ..	1ᵃ	Do.	Do.	..	..	..
Picea morinda ..	1ᵃ	Do.	Do.	..	..	..
Abies pindrow ..	1ᵃ	Do.	Do.	..	..	..
Bombax malabaricum ..	1ᵃ	Do.	Do.	..	..	..
Shorea robusta ..	1ᵃ	Do.	Do.	..	..	..
Pinus longifolia ..	1ᵃ	Copper Stearate 2% (in earth oil)	Do.	..	..	..
Pinus excelsa ..	1ᵃ	Do.	Do.	..	..	..
Picea morinda ..	1ᵃ	Do.	Do.	..	..	..
Abies pindrow ..	1ᵃ	Do.	Do.	..	..	..
Bombax malabaricum ..	1ᵃ	Do.	Do.	..	..	..
Shorea robusta ..	1ᵃ	Do.	Do.	..	..	..

a=Rectangular specimens of size 2′ × 2″ × 2″.
b=Round specimens 2′ long.

laid down in the Graveyard at New Forest—(concld.)

Date of laying	Date of last inspection	Summary of the condition of the specimens at last inspection					Average life	
		Number sound	Number slightly attacked	Number moderately attacked	Number badly attacked	Number destroyed	Years	months
4–5–35	21–2–52	..	..	..	..	1	..	7
,,	,,	..	..	..	..	1	5	7
,,	,,	..	..	..	..	1	..	7
,,	,,	..	..	..	..	1	7	7
,,	,,	..	..	..	..	1	3	7
,,	,,	..	..	..	..	1	6	7
,,	,,	..	..	..	..	1	..	7
,,	,,	..	..	..	..	1	4	8
,,	,,	..	..	..	..	1	4	8
,,	,,	..	..	..	..	1	7	7
,,	,,	..	..	..	..	1	1	11
,,	,,	..	..	..	..	1	2	7
,,	,,	..	..	..	..	1	..	7
12–3–30	7–1–54	..	..	..	..	1	10	8
,,	,,	..	1	..	..	..	..	..
,,	,,	..	..	1	..	..	..	..
,,	,,	..	..	..	1	..	..	..
,,	,,	..	..	..	..	1	16	9
,,	,,	..	..	..	..	1	10	8
,,	,,	..	1	..	..	..	..	..
,,	,,	..	..	1	..	..	..	..
,,	,,	..	1	..	..	..	..	..
,,	,,	..	1	..	..	..	..	..
,,	,,	..	1	..	..	..	..	..
,,	,,	..	..	..	..	1	7	9

TABLE NO. 2.

Comparative prices of the preservatives

Preservative	Address of the suppliers	Sale price	REMARKS
1. Copper naphthenate	M/S. Standard Vacuum Oil Co., American Barracks, Queensway, NEW DELHI	Rs. -/12/5 per lb.	Contains 2% metallic copper
2. Copper and zinc naphthenate (Hardiproof)	M/S. Addisons Paints and Chemicals Ltd., Sembiam, Madras – 11	Rs. 1/2/7 per lb.	..
3. Copper Abietate (Preservative-cum-varnish)	..	Rs. -/8/6* per lb. Rs. -/10/-* per lb.	copper content 2% copper content 3%
4. Zinc Abietate (Preservative-cum-varnish)	..	Rs. -/9/6* per lb.	zinc content 6%

* Anticipated costs.

Approximate prices of various ingredients required for the manufacture of copper and zinc abietates

		per lb.
Resin	Rs.	-/4/5
Benzene	,,	-/7/-
Zinc (Electrolytic)	,,	-/10/-
Copper (Scrap)	,,	1/8/-

SCIENCE NOTES

I

Preliminary note on the debudding trials on *Pinus longifolia* in New Forest, with a view to grow knot-free timber

SUMMARY

Height growth is not adversely affected by the annual debudding when compared to no debudding but the rate of growth is retarded if repeated debudding (4 times in a year) is done. Debudding increases formation of epicormics and becomes a difficult operation after some time.

Trade in timber suffers a great deal on account of rejections brought about by loose knots, which are one of the major defects in timber. In a group of saplings or a crowded stand, natural pruning of side branches takes place in the case of species which are self pruners. However, such timber is not altogether free from loose knots. Various methods of artificial pruning of the side branches to encourage the joining up of the green knots with the surrounding tissue for improving its quality, have been tried in forestry practice. Among them the removal of live branches from the lower portion of the trunk is one. Interest has also been aroused in a new method of pruning variously known as "finger budding", "Russian pruning", "bud pruning" or debudding or "Krotkerich's pruning". The method consists in the annual removal of all lateral buds or very young shoots, found, around the terminal bud or along the stem. The removal of the buds on the stem commences from a height of 2 to 4 feet (3 ft. in this experiment) from ground level. The branches below this level are not removed, but allowed to grow and manufacture food material to the growing stem. The operation is continued until a desired length of clean (branchless) bole has been obtained, after which the tree is allowed to grow normally and develop a good crown.

In order to study the effect of 'debudding' on young *Pinus longifolia* an experiment was started in January, 1950 in compartment Nos. 32 and No. 18 of the Golf Course block of the Silvicultural Research Garden, Dehra Dun. The experiment was started with two treatments "*debudding*" and "*no debudding*" – (control). On inspection of the plots in April 1950, it was observed that the plants from which lateral buds around the leading shoots had been removed, develop a number of new buds and epicormic branches which surround the debudded portion very thickly and, therefore, prevent the development of the main shoot. The branches are formed by the elongation of the dormant fascicle buds. It was, therefore, decided to repeat the debudding operation within a year. Debudding was, therefore, repeated in April, May, November and January every year.

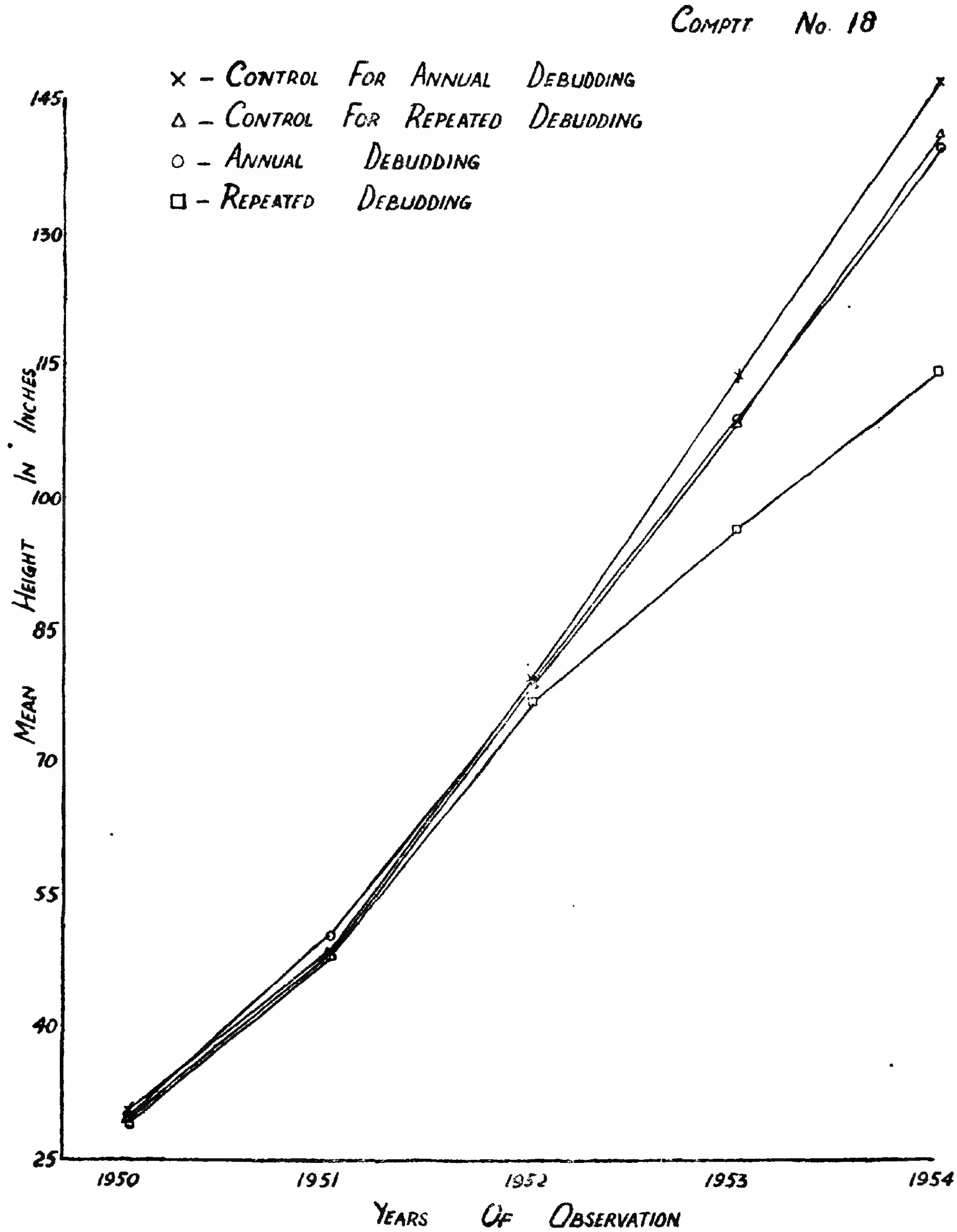
The plantation of *Pinus longifolia* in compartment No. 32 was raised in June, 1945 by sowing seeds of Kagan origin in lines 6 feet apart and the plantation in compartment No. 18 in July, 1946 by line sowing with seed of the same origin. The age of the plantation in compartment No. 32 was $5\frac{1}{2}$ years and the plantation in compartment No. 18 was a year younger.

In compartment No. 32, at the beginning of the experiment, 39 pairs of plants comparable by height and diameter, were taken. In each pair one plant was allotted at random to the debudding treatment called "A", the other was not debudded; this treatment was called "B". The plants under "A" treatment were divided into 18 comparable pairs by height and in each pair one plant was "repeatedly debudded" (debudded 4 times in a year)

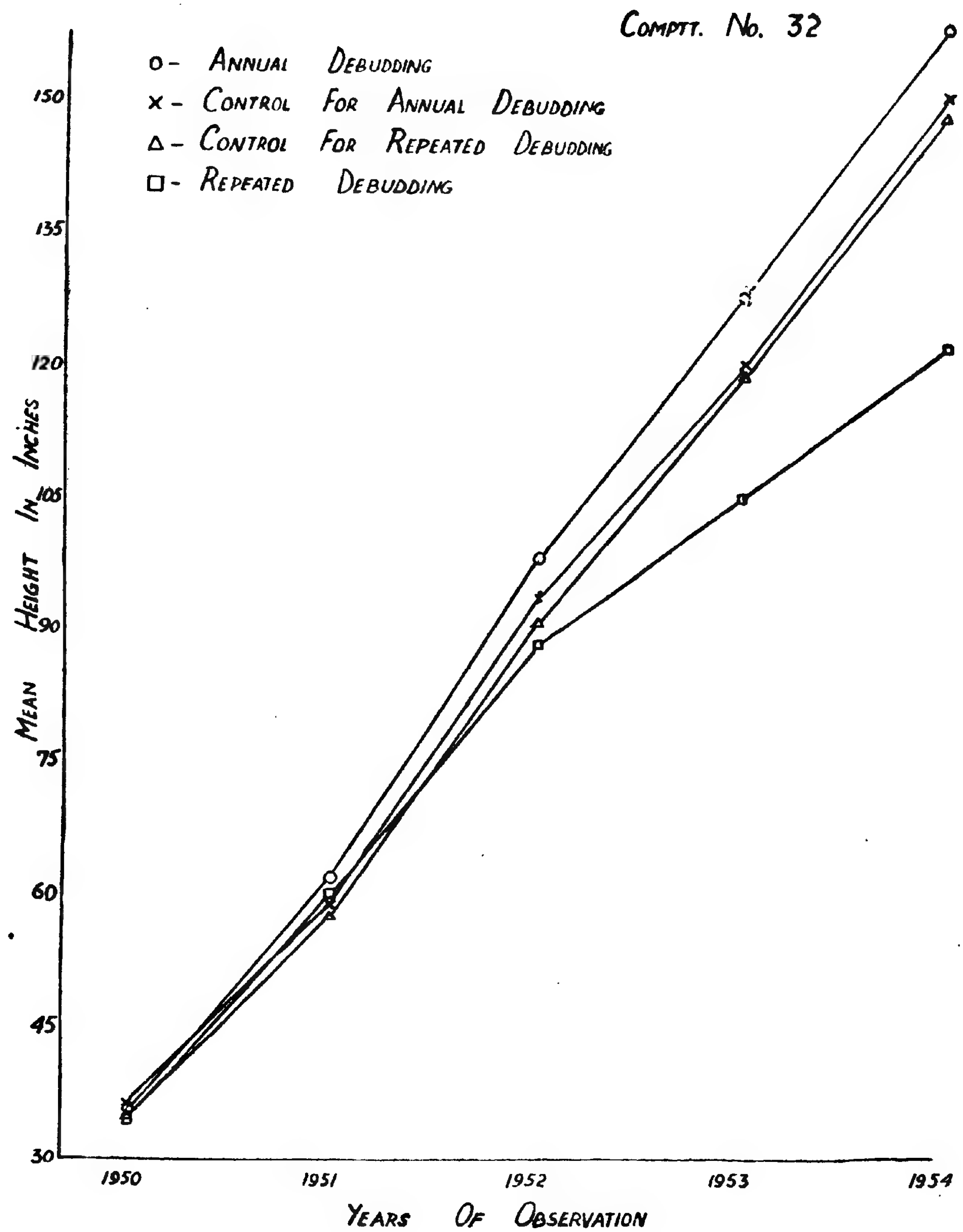
Species: *Pinus longifolia—Compartment No. 18 – Age of the plantation at the initiation of the experiment 4½ years*

Character	No. of pairs	Mean+S.E. (in inches) Height increment		Significance of difference	No. of pairs	Mean+S.E. (in inches) Height increment		Significance of difference	No. of pairs	Mean+S.E. (in inches) Height increment		Significance of difference
		Repeated debudding	Annual debudding			Repeated debudding	No debudding			Annual debudding	No debudding	
Initial height on 18-1-50 ..	20	29·3±0·24	29·5±0·24	N.S.	20	29·3±0·18	29·5±0·18	N.S.	22	30·0±0·16	30·3±0·16	N.S.
18-1-50–21-1-51	20	18·7±1·61	19·6±1·61	N.S.	20	18·7±1·44	18·6±1·44	N.S.	22	20·4±1·26	18·2±1·26	N.S.
21-1-51–19-1-52	20	28·8±2·37	28·2±2·37	N.S.	20	28·8±1·75	30·9±1·75	N.S.	22	28·9±1·82	31·0±1·82	N.S.
19-1-52–21-1-53	19	20·3±2·96	28·9±2·96	N.S.	19	20·3±2·12	30·1±2·12	†	22	29·8±1·99	34·5±1·99	N.S.
21-1-53–27-1-54	17	18·9±2·85	32·4±2·85	†	17	18·9±1·60	32·8±1·60	‡	22	31·8±2·79	33·2±2·79	N.S.
Total height up to 27-1-54 ..	17	114·7±8·89	139·1±8·89	N.S.	17	114·7±5·77	141·6±5·77	†	22	140·8±6·58	147·2±6·58	N.S.
Compartment No. 32. Age of the plantation at the time of initiation of the experiment 5½ years												
Initial height on 18-1-50 ..	18	34·5±0·40	35·4±0·40	N.S.	18	34·5±0·17	34·9±0·17	N.S.	21	35·8±0·20	36·2±0·20	N.S.
18-1-50–21-1-51	18	25·5±1·58	25·1±1·58	N.S.	18	25·5±2·13	22·8±2·13	N.S.	21	26·1±1·36	23·0±1·36	N.S.
21-1-51–18-1-52	18	28·7±1·89	33·8±1·89	N.S.	18	28·7±2·23	33·4±2·33	N.S.	21	36·3±2·09	34·6±2·09	N.S.
18-1-52–20-1-53	18	16·7±1·49	28·4±1·49	†	18	16·7±1·40	27·9±1·40	‡	21	29·6±1·66	26·5±1·66	N.S.
20-1-53–27-1-54	17	17·0±1·58	29·4±1·58	‡	17	17·0±1·53	31·1±1·53	‡	21	30·2±1·75	30·0±1·75	N.S.
Total height up to 27-1-54 ..	17	122·6±4·02	150·2±4·02	‡	17	122·6±5·85	148·3±5·85	†	21	157·9±5·12	150·4±5·12	N.S.

N.S. Not significant at 5% level of probability.
† Significant at 1% level.
‡ Significant at 0·1% level.



Comptt No. 18
× – Control For Annual Debudding
△ – Control For Repeated Debudding
○ – Annual Debudding
□ – Repeated Debudding
Mean Height In Inches
145
130
115
100
85
70
55
40
25
1950
1951
1952
1953
1954
Years Of Observation



COMPTT. No. 32
o - ANNUAL DEBUDDING
x - CONTROL FOR ANNUAL DEBUDDING
Δ - CONTROL FOR REPEATED DEBUDDING
□ - REPEATED DEBUDDING
MEAN HEIGHT IN INCHES
150
135
120
105
90
75
60
45
30
1950
1951
1952
1953
1954
YEARS OF OBSERVATION

and the other was debudded only once a year. Similarly, in compartment No. 18, 42 initially comparable pairs of plants were taken. Later on from the plants under "A" treatment, 20 comparable pairs by heights were taken, and one plant of each pair was allotted to the "annual debudding" and the other to the "repeated debudding" treatments. The operation was carried out when the buds were tender and just started to swell so that they may be expeditiously pulled out by the fingers and the resulting scars may quickly heal up. At the time of the first operation a few branches on some trees had to be clipped. In order to have the level of the residual basal branches more or less uniform, branches below 3 feet from ground level were not clipped. The branches removed at the beginning of the experiment were not more than 1 inch in diameter and the small scars left by their removal healed up during the year; it is, therefore, very unlikely that the quality of the timber will suffer owing to the debudding operation.

The height growth of the year and the mid-diameter of the annual shoot were recorded every year in January; these data were analysed. The results of height analysis are given in the enclosed tables. The observations from the two compartments have not been pooled in view of the difference in age of the plants. The analysis of the results are kept separate.

The mean heights of plants under the different treatments have been shown graphically for compartment Nos. 18 and 32 during the period 1950 to 1954.

Tentative results—The results clearly indicate that the mean rate of growth of plants which were repeatedly debudded, is less than that of those which were debudded either annually or were not debudded at all. There was no significant difference between the last two treatments. An examination of the timber when the trees are older will indicate the effectiveness or otherwise of the treatment given for the production of the knot-free timber.

General remarks—(i) Debudding induces formation of abundant epicormics and encourages growth of the dormant buds on the year's shoot as well as in the region where, excepting the leading shoot, all the other buds had been removed. The plants which had not been subjected to the debudding treatment produced a comparatively small number of epicormic branches on the bole. These were mostly at the end of the terminal cluster.

(ii) The lower branches which are left unpruned near the ground may increase fire hazard in young crops. These branches prune themselves off naturally much earlier in plants which are not debudded.

(iii) The vigorous lateral growth put on by the lower branches makes it difficult to carry out the debudding after a few years, and even a tree ladder sometimes fails to help owing to want of free space close to the foot of the tree for placing the ladder in position.

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II

Preliminary note on the use of Butyle Ester in eradicating Lantana

SUMMARY

The note indicates how Butyle Ester, in suitable concentrations, can be sprayed effectively to kill lantana, *without having to cut back the bushes initially*, as this operation is often impracticable in forestry practice.

Attempts at finding a method of eradicating this obnoxious weed have been made in the past but with no appreciable success. Sodium chlorate spray is one of the chemicals used with some success. Again, a solution of sodium aresnite when applied to the cut stem of the bush has claimed about 65% kill but the danger of poisoning the livestock with this chemical has prevented its wider application. The only way of keeping the spread of lantana in check is by digging it out by the roots or burning it year after year during the dry season, but these methods are costly and cannot be applied over large areas, though they are both fairly simple.

To-day there are several weedicides on the Indian market. One such product made by Plant Protection Ltd. Yalding, Kent, namely, *Butyl Ester* was received some time ago for trials on *Lantana* growing in the Silvicultural Research Garden of the Forest Research Institute. The ester was obtained in three concentrations (i) Y.F. 2619 mixed 2, 4-D/2, 4, 5-T, n Butyl ester containing 0·25% acid equivalent, (ii) Y.F. 2717–2, 4, 5-T, n Butyl ester, containing 35% acid equivalent and (iii) Y.F. 2618–2, 4, 5-T n, Butyl ester with 50% acid equivalent. All these concentrations are in liquid form which, on mixing with water, assume milky colour just as phenol does when diluted with water. These esters are not corrosive to the skin and can therefore be safely handled.

Experimental details—The esters give a 0·3 per cent aqueous solution, i.e., 3,000 p.p.m. (0·3%) spray when ½ gallon of the concentrated ester is mixed with 100 gallons of water. Concentrations used for spraying on the lantana bushes were 0·3%, 0·6%, 0·15% ; these were made by adding 140·6 c.c., 281 c.c. and 70·3 c.c. of each ester to 6¼ gallons of water. Thus the ester containing 25% acid equivalent had the treatments denoted by A_1, A_2 and A_3, the other containing 35% acid equivalent had B_1, B_2 and B_3 and the third containing 50% acid equivalent had C_1, C_2 and C_3 where A, B and C represent the three esters and numbers 1, 2 and 3 denote the dilutions 0·3%, 0·6% and 0·15% solution. Owing to the limited quantity of the esters available for trial, other dilutions could not be tried. Thus there were 10 treatments in all including one control.

60 comparable bushes, out of 110 bushes initially measured, were allotted at random to the ten treatments, giving 6 replications for each treatment. The approximate crown spread (length × breath of the bushes) was the criterion for establishing initial comparability. An important thing to note in connection with this experiment is the fact that the *bushes were not cut back* before treatment. This was done with a view to see whether lantana can be eradicated without incurring any expenditure on the initial cutting back of the bushes, *because such cutting is often impossible* in forestry practice. This cutting of lantana over vast areas in forests is a tremendous task, too difficult to perform either owing to prohibitive cost or due to dearth of labour.

Spraying was done during the 2nd and 3rd weeks of July, 1952 by means of sprayers operated by a foot pump. The esters were diluted immediately before use, and the entire leaf surface above and below were covered with the spray. After a day or two of the spray, the growing shoots began to show signs of wilting and the leaves began to droop. The bushes treated with the esters assumed a very unhealthy look by about the first week of August when

Dates of observation	A₁ Bush Nos.		A₂ Bush Nos.		A₃ Bush Nos.		B₁ Bush Nos.		B₂ Bush Nos.		B₃ Bush Nos.		C₁ Bush Nos.		C₂ Bush Nos.		C₃ Bush Nos.		D Bush Nos.
	Dead	Dying	Dead	Dying	Dead	Dying	Dead	Dying	Dead	Dying	Dead	Dying	Dead	Dying	Dead	Dying	Dead	Dying	All healthy
							(Serial number of the bushes)												
31-1-53	62 78* 11*	.. 69 85 105	10 58 71* 83 91 104*	.. ..	5*	.. 14 28 82 88 110	16 17* 54 89	2 80	7 56 57 72 87 ..	4	65 92* 101	12 21 32	70	13 24 33 73 107 ..	39 60 102*	75 55 106	.. ..	8 64 67 77 98 99	3 9 26 40 86 97
30-5-53	62	11* 69 78* 85 105 ..	10 58 83 91	71* 104*	88	5* 14 28 82 88 110	2 16 89	17* 54 80	7 56 57 72 87 4	4	65	92* 101 12 21 32 ..	33 70	13 24 73 107	59* 60 55* 75	102* 106	Nil	All sprouted	All healthy
20-7-53	62	All resprouted	10 58 83 91	71 104	88	5 14 28 82 88 110	2 16 89	17 54 80	All dead	4	65	92 101 12 21 32 ..	33 70	13 24 73 107	59* 60 55* 75	102 106	Nil	All sprouted	All healthy
23-1-54	62	All resprouted	10 58 83 91	71 104	88	5 14 28 82 88 110	2 89	17 54 80 16	All dead	.. ..	.. ..	92 101 12 21 32 ..	33 70	13 24 73 107	55* 60 75	59* 102 106	Nil	All sprouted	All healthy
14-5-54	62	All resprouted	10 58 83 91	71 104	88	5 14 28 82 88 110	2 89	17 54 80 16	All dead	4	65	92 101 12 21 32 ..	33 70	13 24 73 107	60 75	55* 59 102 106	Nil	All sprouted	All healthy

* Resprouted.

the leaves and the growing tips were almost dead, but new shoots from the lower portions of the branches, where there was no shoot before, began to emerge. This new growth of branches developed into a second layer and took the place of the top layer of branches which had become almost leafless. Some of the bushes began to recover and by the end of the rainy season in September, these bushes were mostly alive but looked unhealthy. The spraying was repeated in the second week of November ; after this the bushes were kept under observation. The results, to date, are given on page 575.

From that table it will be seen that some lantana bushes which had been classified as dead 2 years earlier resprouted later on from their underground parts.

The number of dead lantana bushes on 14–5–54 under each treatment is given below :—

Particulars	A_1	A_2	A_3	B_1	B_2	B_3	C_1	C_2	C_3	D
No. of bushes originally treated	6	6	6	6	6	6	6	6	6	6
No. of bushes dead ..	1	4	1	2	6	1	2	2	nil	nil
%dead	16·7	66·7	16·7	33·3	100	16·7	33·3	33·3	nil	nil

Tentative conclusions—The treatment B_2, i.e., 0·6% of Y.F. 2717 2, 4, 5-T, n – Butyl Ester containing 35% of acid equivalent was found to be the most effective for killing lantana. Bushes killed by this treatment did not resprout at all but, in other cases although the mortality percentage appeared to be high in the beginning several bushes resprouted, so that the ultimate percentage was much lower. Next to this the A_2 treatment, i.e., 0·6% of Y.F. 2619 mixed 2, 4-D/2, 4, 5-T n – Butyl Ester containing 25% acid equivalent is the most effective with 66·7% of kill.

The results indicate that under the conditions prevailing in the Research Garden of the Forest Research Institute, Butyl Ester in suitable concentrations can be used to kill lantana bushes.

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CORRIGENDUM FOR THE JULY, 1954 ISSUE OF THE *INDIAN FORESTER*

Letters to the Editor, p. 420, line 3 of letter No. II ; in place of *Kolhan* please read *Porahat.*

NEED FOR BIOAESTHETIC PLANNING*

BY MAHESH KUMAR, M.SC., A.I.F.C., P.F.S.
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We have bid fare the era of ruthless exploitation of trees in the normal expansion and growth of cities. Inhabitants of cities and towns now realize that shade trees are a valuable asset to their communities. Now, the stately double rows of trees along highways possesses a distinctive appeal to them. As a consequence, new plantings are being made along tree – barren commercial highways and public places.

History endorses the need for shade avenues—In ancient India planting of trees to provide shade to way-farers and cattle was ragarded as an act of piety. Emperor Ashoka was one of the earliest monarchs who planted shade trees along roads and in public places. The Moghuls, too, realized the necessity of shade on the roads which they constructed. But there was no conscious planning, and *Peepul* and *Pakar* trees were indiscriminately mixed with *Neem, Imli* and *Mahua* trees. It is only in Kashmir that they showed some preference for planning and planted magnificient avenues of Chenar along the banks of Jhelum. Conscious planning of avenues in Europe dates from the sixteenth century when Francis I of France adopted an organized scheme of planting Lombardy poplars along the main roads of France.

The first example of conscious planning to bring the beauties of nature within the reach of the common man through well planned parks and squares, beautiful roads, and bioaesthetically designed buildings is found in the Garden City of India – Lucknow ; and this city was born with its scenic grandeur as early as in 1780.

Tree as an object of beauty—You will ask ? Why were the trees held in high esteem ? One nature lover, Prof. F. A. Waugh remarks : "Next to the human form the most beautiful unit in nature is a tree". A thing of beauty is a joy for ever, says Shelley. Trees do rightly contribute to recreational and aesthetic values. Wordsworth's fellow – learner of "the lesson from vernal wood" would appreciate that "trees suggest the eternal verities".

Recreational and aesthetic value of trees—The place occupied by trees in their recreational and aesthetic phases is rarely appreciated, although the desirability of a fine grove and the beauty of street and park trees is fairly conceded. Most look at part of the picture, and seldom consider the situation as a whole. There are some million miles of state roads in the country traversed by crores of citizens on both recreational and business trips. Many of the frequenters of the highways appreciate the beauty and comfort afforded by trees along the right-of-way. The extensive building of park-ways, recent and in progress, shows a distinctive trend towards landscaping and planting of native trees and shrubs. This is believed indicative of the increased part to be played by highway trees in the future.

Trees line the road to prosperity—The trees of the country have contributed largely to the prosperity of the nation. They are important natural resources and in the preferred residential areas there is a more general appreciation of the place trees occupy in the adornment of roadside parks and private premises and also of the effects they have upon human health and happiness. Needless to say "Beauty walks hand-in-hand with health".

Trees add attraction to home grounds—It is difficult to imagine home grounds without trees. A lawn without trees, even though it be a small one, does not possess the attractiveness and character of one suitably planted, in which the blaze of autumnal colours challenges the brilliancy of the rainbow. Will the values in trees not justify expenditure to conserve the investment ?

Trees radiate beauty and inspiration for research, higher learning and noblest ideals—Trees should be an important part of the physical equipment of most educational institutions. It

* I take this opportunity to express my gratitude to various authors whom I have quoted herein.

was once stated that Mark Hopkins at one end of a log and a student on the other constituted a university. It is an excellent simile. In noting the obvious emphasis on the inspired teacher and the student thirsting for knowledge, most overlook the fact that this ideal university depended for its support upon a tree and miss the implication that the log was in a shaded comfortable place. The Vishwa-Bharati, Shantiniketan, of Tagore is a case in hand.

Trees upon the campus afford a beautiful setting for the buildings and radiate beauty and inspiration throughout the year. Newton gained his inspiration under a tree. Who can say that trees or groves of trees have not aided materially in the development of higher ideals ? Truly "One impulse from vernal wood may teach you more of men and science than all the sages can".

Trees as more suitable and lasting memorial—There are no less possibilities of tree planting in cemeteries. In foreign countries some of the most attractive cemeteries are adorned with magnificent trees. One cannot help but feel that in most of the cases a living tree is a more suitable and lasting memorial than an expensive monument. Trees supply a character and atmosphere which can be obtained in no other way. Could there have been a better setting for the Bodhisatta, Gaya, than the flagrant banyan tree ?

Raising the morals and creating an aesthetic sense in slum dwellers—Beautiful roads, well planned parks, and squares will bring the beauties of nature within the reach of the common man in our towns and cities. "The dwellers of slums will also appreciate the beauty and splendour of flowering trees, at least their children will, who will have the opportunity of growing up in new environment. Those who have lived in filthy surroundings for generations cannot be suddenly transformed in a few years into lovers of beauty. But the attempt is certainly worthmaking and result will be tangible after some time".

Naming of roads and streets simplified—Bioaesthetic planning will also simplify the problem of naming roads and streets. The streets can be named after the flowering trees which are grown on the road, such as *Amaltas* Avenue, *Kachnar* Avenue, Gulmohar Avenue, Jacaranda road, Asoka Avenue. Not only the roads will be readily recognizable, but this device will also enable the citizens to familiarize themselves with our common flowering trees. Some imaginative pioneer has actually named a road in Lucknow as Millingtonia Avenue after *Millingtonia hortensis* and in Forest Research Institute compound as *Jacaranda* road after *Jacaranda mimosaefolia*. This device shall also bring to an end the rivarly between the local public men for the roads to be named after them.

The romantic aspect of trees—Into the civilization we have to blend the serene spirit of the forest. The old want forest seclusion far from the maddening crowd. The young, too, want a forest hermitage. For it is the birthplace of flowers, and the haunt of birds and butterflies, and the hidden nooks are waiting there for the thrill of lover's whispers. A bench placed underneath a cool and shady grove of Asok has its own charm.

Plains planned to befit the Himalayan grandeur—The Himalayan tract exhibits Nature at her best and its luxuriant flora, its sylvan retreats and sunlit summits present to the eye some of the most beautiful and romantic scenery in the world. Scattered over its sharply undulating surface are famous temples and hill stations – sacred Badrinath, gay Mussoorie, which attract pilgrims and tourists from far and near. The unparalleled beauty of the magnetic peaks of the Himalayas has attracted a host of tourists from all over the world. With ever increasing facilities of communication the tourist traffic is bound to increase. But what will they see on their way to the Himalayas ? Shall we present to them the unsightly sight of the treeless barren plains ? There should be something in the plains too, to match with the grandeur of the Himalayan meadows and its pine-scented forest. The bioaesthetic planning is intended to achieve this end.

Peripheral planting as protection against heatwaves—There are some towns which fall from year to year in the grip of heatwaves (i.e., Nagpur). The state of the towns bordering the Rajputana Desert, viz., Agra, Delhi, etc., is still worse. Such towns, as a whole, need protection by tree planting around the periphery. But such plantings also should exhibit some sort of aesthetic orderliness. For it is from these peripheral plantations that one gets his first impression about the town – whether grim or pretty.

Evils of industrialization counteracted by trees—The industrialization of the country will give rise to newer problems. The effects of smoke and soot from the mills overhanging the cities and that of the exit water from factories will have to be counteracted by suitable plantations in and around the site of the manufacturing centres. The factories preparing edibles like butter, biscuits, etc., will have to be screened from the dust of town streets. This again can be attained by the planned planting of the factory compunds by trees which act as dust filter owing to the character of their foliage like the *Asoka* tree (*Polyalthia longifolia*).

Concealment by trees – camouflage reduces bomber efficiency—Trees serve man and his needs equally in war and in peace. Present war conditions emphasize the possibilities of camouflage by the use of trees. Soon the need may be urgent. Both immediate and future conditions warrant careful planning. There are two important phases : viz., the utilization of existing trees for camouflage and the possibility of planting or growing trees for future needs in military centres, airplane fields, etc.

Trees our friend—Despite the use of trees in War, they are our great friends.

" For trees, you know are friends indeed,
They satisfy such human need,
In summer shade, in winter fire,
With flowers and fruit meet all desire,
And if a friend to man You'd be,
You must befriend him like a tree. "

—*Charles A Heath.*

And this supernatural friendliness with trees had actually attained its climax in ancient India wherein we find the 'Kanva Rishi' performing the marriage of *Madhabi Lata* with *Am*, and the flower friends of Shakuntala weeping for her as she leaves for her husband's home. What an excellent example ? Of oneness of the whole creation, or at least of innate friendship of human beings with trees.

Obligation to shade and ornamental trees—And so this generation holds a trusteeship obligated to pass on unimpaired its glorious heritage of shade and ornamental trees, for

"Shade trees are not thine,
NOR MINE"
They are OURS.

ROAD DECORATION is not gardening, nor is it agriculture, and still less is it civil engineering. It requires considerable skill to get out a plantation scheme, it requires skill to establish the trees and shrubs. It requires just as much skill, and causes a great deal more anxiety to keep the material growing.

Need for maintenance—More than one well – thought out and properly launched planting scheme has fallen by the wayside in recent years, because the necessity for efficient maintenance has been overlooked.

Qualification of a bioaesthetic planner—In fact, this is not the work of a surveyor, an engineer pure and simple, or the horticulturist and much less *that of a politician*. It is the work of a specialist, with some knowledge of roadwork, entomology, plant disease, tree surgery and manuring – a specialist who not only knows when to plant, but when NOT TO PLANT.

FOREST TYPES IN JUBBAL FOREST DIVISION OF HIMACHAL PRADESH

BY SATYA VRAT

Divisional Forest Officer, Jubbal Forest Division

Introduction—The Jubbal Forest Division of Himachal Pradesh is the richest Division of the State so far the forest wealth and the revenue are concerned. These forests have been well preserved in the past and reproduction, nearly in all cases, have been ahead of the pace of exploitation.

In this article the forests of Jubbal have been described on ecological basis. On the same basis the writer had written Chapter II of the revised Working Plan of Jubbal forests in 1950. Hitherto the practice has been to describe these coniferous forests on a zonal basis and all existing Working Plans and also recently revised Working Plans of hill divisions have adopted this age-old procedure.

The description follows Champions' types as given in his book "A preliminary Survey of Forest Types of India and Burma".

Forests of the erstwhile Jubbal State—These forests, scattered as they are over an area of 288 square miles, from the lowest elevations of 2,300 feet near Minus to 11,992 feet on Chur peak, present a variety of physical features, leading to diversity in vegetation. In the hills, altitude and aspect are the main factors determining the physiographic variation in the composition and condition of the crop within the general coniferous oak climate formation. The horizontal change from east to west in this climate formation is determined by the amount of rainfall and snow fall.

There are several ways in which a forest can be divided into units for descriptive and management purposes. The units recognized previously were artificial and did not take into account the site factors as a whole, e.g., classification of vegetation purely on one aspect of site, i.e., altitude, and so zonal description of vegetation has been the rule in old Working Plans. More knowledge has been gained in the last 30 years about the effect of temperature, soil moisture, aspect and other site factors on the character and growth of the forests. Now, attempts are being made so that divisions, which are temporary and obviously made for economic reasons may be changed to be in harmony with the natural units as recognized by plant ecologists.

The kind and degree of differences necessary for the demarcation of forest types is not very well understood at present. Nevertheless, the attempt to classify forests into various types taking into consideration site factors as a whole is laudable in itself.

Clements, in 1909 emphasized the desirability of increased use of forest types in the practice of forestry ; he said :

"The application of forest types to forestry brings them into harmony with the fundamental principles of ecology. It places the forester and ecologist on the same basis in so far as the study of forest vegetation is concerned......Detailed knowledge of a forests development is the only scientific foundation for its treatment, but such knowledge is possible only through an investigation based on factors, development and structure''.

Zon had expressed the same opinion in 1906 that there can be no real progress in our silvical studies until the question of forest types has been solved.

Unfortunately forestry in India has not made much progress on the line. In fact no continuous and methodical study has been carried out on the subject. It was H. G. Champion who made praiseworthy efforts in this respect and his book "A Preliminary Survey of Forest Types of India and Burma" is the only classic in India of its kind.

The description of Jubbal forests in this article, therefore, follows Champion's types as described in his book. The main types are :—

(1) Sub-tropical Pine Forests.

(2) Moist Temperature Forests.

(*a*) Lower Oak coniferous.

(*b*) Middle Oak coniferous.

(*c*) Upper Oak coniferous.

(3) Alpine forests.

(*a*) Birch-Fir.

(*b*) Birch-Rhododendron.

Sub-tropical Pine forests—This type mainly consists of inflammable pine forests with or without an evergreen undergrowth. In Jubbal, this type is constituted by the ***chir*** pine forests found between 3,000 and 6,000 feet in elevation. The area of demarcated ***chir*** forests is 8,682 acres, i.e., about 14% of the total area under forests. Total area of ***chir*** forests is 10,067 acres. The forests lie mainly along Shalvi gadh, Hamalti gadh and Minus and Chaknaut gadhs. They occupy the northern and north-eastern slopes along Shalvi gadh from Shallon to Neoti; both eastern and western slopes along Chaknaut khad from Jalara to its junction with Shalvi gadh.

On the whole they are pure *chir* forests of I/II quality but very open due to their proximity to habitations and repeated fires. Nearly one-fourth of the area in these forests is blank. Grass cutting and heavy grazing tend to perpetuate and extend these blanks.

These forests contain pole crops and are honeycombed with blanks and patches of cultivation. Older girth classes have been ruthlessly removed for being given to the *zamindars* and under the selection fellings of the past. Seedling and sapling stages are very deficient, barring a few area. Generally these *chir* forests have been heavily worked.

Unfortunately, these forests cannot be closed to grazing and being close to villages the people are even hostile to their being demarcated. As already mentioned, ***chir*** forests are almost pure in the lower parts, but higher up they are mixed with ***Quercus incana*** which occupies the moist ravines and the *chir* the intervening spurs.

As an understory ***Pieris ovalifolia*** and ***Rhododendron arboreum*** are invariably to be found. Near Chopal, Nerwa, Kiarla heavy admixture of ***ban*** oak is to be seen and ***chir*** is mixed with ***kail*** in the upper limits.

The undergrowth, associated with ***chir*** contains ***Rhus*** spp., ***Berberis*** spp., ***Prinsepia utilis***, ***Xanthoxylum alatum***, ***Punica grantum***, ***Contoneaster microphyla***, ***Rubus*** spp., ***Zizyphus xylopara*** and ***Woodfordia floribunda***. Grasses form a luxuriant growth as the forests are very open and are burnt regularly.

The quality of the crop varies considerably with the soil, the trees being stunted on rocky ground and shallow soils, while they reach very good height in favourable localities (a tree – 102 feet high having been measured in Nakeora *dehat*).

Chir pine is known to grow on variety of geological formations. Here it generally occurs on hard clays and quartzite in a pure form. Better quality *chir* is found here on soils

formed from mica schist and softer lime-stones. On mica schist it is always found mixed with *ban* oaks and other broad leaved species.

Moist temperate forests – (a) *Lower oak coniferous*—This type consists of deodar with some blue pine and *Quercus incana*. The real climatic formation is the oak coniferous formation and not the pure coniferous forests. The existence of pure coniferous stands is the result of biotic influences, in the shape of lopping and felling of the oaks since times immemorial. The forests of this type tend to attain a comparatively mesophytic character when they remain uninterrupted by human agency. These pure coniferous forests may, therefore, be called a *management type*.

These forests are found at elevations of from 5,000 to 8,000 feet and exhibit a variety of associations within the type which are governed by local conditions such as aspect, soil and drainage. This type, therefore, contains pure deodar forests, pure *kail* forests and mixed *kail* and deodar forests. Oaks invariably form part of all these sub-types and their absence or presence shows the extent of human interference in the natural community.

(i) *Deodar sub-type*—This sub-type shows apparent climax vegetation of the locality under given conditions. Its pure formation is certainly due to removal of the broad leaved species by *zamindars* and the department in the interests of deodar ; similar has been the fate of *kail*. Such forests of deodar are naturally regenerating themselves and the salient feature is that reproduction is of mixed deodar and *kail* and not of deodar alone. Conditions of soil in such forests favoured with light grazing by horned cattle, are such that the reproduction of conifers appears everywhere without fail wherever a slight break in the canopy occurs. Reproduction has appeared even under the closed canopy in many forests.

Deodar is a very exacting species and pure deodar forests are found only on the best soils and on generally cool aspects, where drainage is good. Pure deodar forests are, however, small in extent and are mainly confined to Deya and Kanda ranges only a few small patches of pure deodar being found in the other ranges, namely, Kuhrali, Kuhl, Dakron and parts of Amta and Chiuna forests of Sarain range and Barhal, Mihana, Rampuri and Kalauntha forests of Barar range.

In all the forests where pure deodar exists the soil is generally a well-drained, disintegrated, sandy loam from mica schist, gneiss and granite. Deodar is of very good quality in Deya and Kanda ranges particularly in Churain valley and Kanda forests. Trees more than 150 feet in height are found in some of these forests.

The deodar crop is mostly in young pole or middle aged stages with old trees (I and II class) scattered in every compartment. This has been the outcome of the selection fellings under the first Working Plan and faulty marking during the period of the Plan under revision. Nowhere does a real mature compact stand ready for regeneration exist. The crop is still very irregular and a commercial yield is found in every periodic block and not confined to P.B.I. Reproduction is profuse everywhere.

In sheltered places and along ravines and *nalas* broad leaved species, such as *ban* oak, *Aesculus-Indica Acers*, *Ulmus* spp., *Cedrela serrata*, *Corylus colurna*, etc., are generally found. The admixture of broad leaves species with conifers is desirable as it leads to the improvement of the quality of the locality and reduces fire hazard.

This type exists close to habitations and it is subject to increasing stress of grazing. Undergrowth is light and generally consists of *Sarcococes saligna*. *Daphne canabina*, *Lonicera*, *Viburnum*, *Indigofera*, *Desmodium*, *Rosa* spp., *Rubus* spp., *Spiraea* spp., etc.

(ii) *Kail sub-type*—Within the same range of elevation pure forests of *kail* exist on hotter aspects, on old grasslands, in abandoned fields and in the forests blanks of 1921 caused

by fires. On pure clay soils or on soils with preponderance of clay, *kail* replaces deodar and exists in more or less stable formation. This formation is more or less a stable edaphic climax. This type is to be seen in Bajathal Compartment I, Kahu Compartment IX and Halau Compartment III, etc. *Kail* forests of Bamta block and Giri and Jhalri forests have come up on old grassy blanks and are of recent origin. They are a Seral type being the first formation on old grassy blanks. Deodar is nearly absent from these areas and so is its reproduction due to lack of seed trees. But deodar reproduction is to be seen where old trees of deodar exist by chance. On the hot southern aspects *kail* holds the ground but here too deodar community does show up in sheltered cool places. *Kail* also exists, in isolated condition in *ghasnis* on poor soils, in stunted form.

Kail of very good quality grows in Gatu Compartment III, Rinjat Compartment I and Khanti Compartment I and Giri forests were it exists on easy, well-drained slopes on loamy soil. It is interesting to note that *kail* disappears on rocks and cliffs and it is deodar which is met with there.

Forests of *kail* are generally much younger than those of deodar. They are mainly in the sapling and pole stages. Older stems above 20 inches diameter are deficient. The existing older trees are found scattered in all the periodic blocks but, generally speaking *kail* forests are more even-aged and uniform in character than deodar forests owing to their recent origin and removal of old diseased trees. Old *kail* trees often bear signs of fungal attack. Their early removal from all the forests is necessary. Younger crops are very congested and unhealthy.

The *kail* forests are regenerating every where with ease. They lie surrounded by villages and are subjected to misuse. Occurrence of fires is now quite common, grazing is heavy and the tendency to practise lopping is increasing in these areas. Inspite of all these malpractices the net result is the increase of area under *kail* crop due to the invasion of grassland by *kail* with better protection in the past, though older *kail* forests are being turned into deodar forests by favouring the latter and higher up spruce is invading in pure forests of *kail*.

Generally speaking, in canopied *kail* forests, undergrowth is very light and is mostly the same as found in deodar forests but the proportion of the deciduous species is more, the common ones among them being, *Berberis*, *Spirea*, *Indigofera*, *Rubus* and *Rosa*.

(iii) *Mixed deodar, kail and spruce sub-type*—By far the greatest area of the forests is occupied by this sub-type, containing all the three species nearly in equal proportion. In this sub-type are found the best specimens of deodar and *kail* trees.

This sub-type generally occupies the cooler, northern slopes having well-drained deep soil. The proportion of broad leaved species is comparatively high. The trees are tall with clean boles and of magnificient size; for example, parts of Jhal, Khanar, Kahu Compartment IV and Amta, Sarain and Chiuna forests. In such forests deodar occupies the spurs and exposed localities, and spruce the cooler and sheltered places while *kail* occurs in warmer places.

There are possibilities of confusing this sub-type with the next type, i.e., Middle Oak coniferous forests because the community of vegetation is nearly the same. Difference lies in the absence of *Abies* and the smaller percentage of *mohru* oak which form a good proportion in the middle oak coniferous forests. Ground vegetation in both consists of such soil indicators such as Maidenhair fern, violet strawberry, etc. Grasses are sparse.

The Forests of this sub-type are very irregular having all classes intermixed. The regeneration of deodar is not sufficient and spruce is ousting the deodar. *Kail*, not finding

suitable environment, tends to become deficient. In the upper tension belt *Abies webbiana* makes its appearance. These forests, ecologically are in a unstable condition. But indications are that, left to themselves they will progress to a type having a greater percentage of spruce.

Conditions have not progressed very far and with a judicious use of his knowledge, a forester should be able to increase the proportion of deodar and *kail* in such areas. These forests should be subjected to heavy grazing, as mesophytic ground vegetation is gaining ground, and deodar should be rarely felled.

Middle oak coniferous forests—The predominant species of this sub-type are spruce, deodar and fir with *Quercus dilatata* as the main associate. The forests are always mixed ones and *kail* invariably comes up in mixture on southern slopes. This sub-type generally exists from 7,500 to 8,500 feet and shows great floristic variations in local associations.

This type may be viewed as a cover type, only showing the community of vegetation present without any regard to its stability. In fact, this type is mainly composed of tension belts of two types in mixed deodar-*kail*-spruce sub-type and Upper Oak Coniferous type.

Deodar is restricted to ridges and spurs. Higher up it is replaced by pure fir forests while in the lower belt spruce is rapidly increasing its proportion.

These forests lie mainly on easy slopes, e.g., Munalag Compartment III, Shanglaog Compartment I, Mulnon Compartment VIII, Naoni Compartments I, II and III, part of Jhond and Muril forests. Forests of this type contains good trees of all species. But attempts should not be made to convert them to pure deodar forests as deodar can only be maintained at an exhorbitant cost. Site conditions are such that deodar will again be ousted or regeration of deodar will be obtained artificially after the rotation. The mixed condition of the crop should be maintained. Lower soil temperatures, thick humus in the higher portion and thick bushes combined with considerable high elevations are not favourable conditions for deodar regeneration. Sheep and goat and buffalo grazing also lead to elimination of deodar while firs often escape the damage.

During the last war some forests of this type were heavily opened up ; these include Pabas Compartment IV, Naoni Compartment III, some parts of Shilla Sarao, Bhairog Compartment IV and Munalag Compartment III. Heavy removal of fir and spruce took place but deodar was retained with the object of bringing in its natural regeneration. Heavy debris encumbering the ground, want of rest from grazing and very heavy opening of the canopy have combined to hamper the regeneration of any tree species. Instead of this regeneration bushes have occupied the area. The proper course would have been to close the area to grazing and to introduce deodar artificially.

Broad leaved species are very common in this type, the dominant species being *Quercus dilatata*.

Taxus baccata forms the understorey in places. *Acer* spp., *Horse-chestnut, Hazel, Ilex, Salix* spp., and *Contoneaster bacillaris* are also found. Dense undergrowth of *Viburnum, Lonicera staphylea, Emodi* and *Salix* encumbers the ground.

2. (c) *Upper oak coniferous forests*—Above 8,500 feet silver fir and *kharsu* oak (Q. *semicarpifolia*) form a distinct crop which is interrupted with small grass glades. This type goes up to the limit of the tree growth. Higher ridges of every valley contain crops of this type.

The best fir forests are met with in Giri Compartment IV where forests exist in an ideal selection condition, all age classses being present. The regeneration of fir is on the whole

fairly satisfactory. But fir forests of Mulnon, Sarain, Amta and Shilla Sarao are not in such good condition owing to heavy grazing by buffaloes. In such areas the older diameter classes preponderate while natural reproduction is negligible. Heavy felling refuse, low temperatures, greater accumulations of humus and heavy weed growth are factors inhibiting regeneration of silver fir. Older trees are generally hollow and malformed.

At higher altitudes, particularly on rocky situations, pure forests of *kharsu* oak are found (Panti, Mulnon, Jhina forests) elsewhere *kharsu* is found mixed up with conifers. Other broad leaved species met with are *Acer pictum, A. caesium, A. caudatum, Aesculus indica, Corylus colurna, Ilex dipyrena, Salix* spp., *Cotoneaster bacillaris, Ulmus* spp., etc.

Heavy bush growth composed of *Viburnum, Cotoneaster bacillaris, Lonicera, Staphlea emodii, Impatiens, Senecios* and *Strobilanthus*, exists. Gujars' buffaloes graze in this zone. In places this grazing is heavy, namely, in Shilla Sarao and Pabas forests. The area is the home of some important medicinal herbs, such as *Podophyllum emodi, Valrina wallichi, Polygonatum verticillatum.*

The importance of these forests has increased now as fir timber is in heavy demand in the market ; so these forests are being brought under scientific management.

Alpine forests—These forests occur above an elevation of 10,210 feet. They consist of conifers with evergreen low broad leaved trees. Two associations of this type are found :

(*i*) Birch-Fir association.

(*ii*) Birch-Rhododendron association.

Alpine forests are not found in Jubbal except to a small extent near Chur peak, where the Birch-Fir association is promiment. *Betula utilis* with high level fir and sprinkling of *kharsu* oak are the principal species. *Rhododendron campanulatum* is also found but not in a gregarious form and this association is negligible. Some medicinal herbs are found but not in any appreciable quantities as large tracts of alpine pastures do not exist. Herbs met with are *Aconitum heterophyllum, Pichorhiza kurroara, Podophyllum emodi, Juniperus macropoda.*

CHARACTERISTICS OF SOILS AND SITE CONDITIONS WITH REFERENCE TO THEIR SUITABILITY FOR THE GROWTH OF SAL (*SHOREA ROBUSTA*) AND ITS NATURAL REGENERATION

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Introduction—Attempts have been made in the past to solve the problem of regeneration of sal but it still remains an outstanding forest problem of economic importance. Hole[1, 2] was one of the first workers to make a systematic study of the ecology and regeneration of sal and according to him the main causes responsible for unsatisfactory regeneration were bad soil aeration and an inadequate supply of moisture. Smythies[3, 4] made certain recommendations for obtaining regeneration. The main one among them was the opening up of the canopy one crown width of seed bearers leaving them 30–40 feet apart. This brings 50–50 grass and shrubs under which sal regeneration is obtained with the help of later operation. Such an opening of the canopy is not, however, universally applicable. Warren[5] states that in Singhbhum 'there is plenty of regeneration lying dormant in a fairly close canopied forest'. Warren further states that the opening of canopy as suggested by Smythies, which he calls "pepper-pot" arrangement, was detrimental to regeneration in Saranda in the Karampada block. This was alleged to be due to root competition for moisture. In contrast with this, in Samtara 16, Bamiaburu, sal regeneration shot up from 2–3 feet to 15–18 feet high in four years under much closer canopy, due to conservation of moisture caused by trenching 25 yards away. Griffith and Gupta[6] made an extensive study of the soils from sal areas in Haldwani and Dehra Dun and were of opinion that (i) sal tolerates a fairly acidic soil (*pH* 4·5–5·5 in subsoil) and the subsoil acidity is caused by sal itself, (ii) accumulation of organic matter to the extent of 2% is not detrimental to sal regeneration, (iii) high ratio of Co_2/O_2 in soil solution is detrimental to sal regeneration and it was found on the basis of culture solution experiments that the critical ratio of Co_2/O_2 is 280/100 and that, (iv) nutrient deficiency in sal forest soil does not appear to be the cause of failure of regeneration.

Further investigation on the soil characteristics and conditions of sal regeneration was done in the forests of Ramnagar and Haldwani. Some of the field investigations are discussed by the author in this paper.

Ramnagar Forest Division – Jaspur compartment 47—This area falls in the Natural Regeneration Experimental Working Circle. In the area we worked, there are lot of whippy (unestablished) plants, but they do not seem to make any progress. They are stagnant and do not grow into established seedlings. In the Divisional Experimental Plot No. 11, winter shrub cutting was started in 1941 but to no great help. On the suggestion of Prof. H. G. Champion some hoeing experiments were done by the D.F.O., but it did not help. There is also the problem of top-drying of the large standing trees in this area. There is no regeneration either *de novo* or coppice.

Sal type—A_2 (Champion's classification), i.e., Dry Gangetic Alluvial sal.

Sal quality—II/III.

Soil conditions—Two pits were examined, namely Pit 1 inside the fenced area where winter shrub cutting is done and the Pit 2 outside the fenced area (control) where no operations are done.

Pit No. 1: (inside the fenced area in Divisional Experimental Plot No. 11, where winter shrub cutting is done). Canopy·2.

0″–13″ Greyish yellow sandy loam
$pH = 7 \cdot 0 – 6 \cdot 5$; Moisture = + (2·6%)
Hardness at surface = 30 strokes
Percolation time on surface = 260 min.
Organic matter = High

13″–51″ Brownish yellow sandy loam
$pH = 6 \cdot 0$; Moisture = ++ (6·4%)
Hardness at 24″ depth = 36 strokes
Percolation time at 24″ = 160 min.
Organic matter = Moderate

51″–76″ 2nd horizon continues
Brownish yellow sandy loam
$pH = 6 \cdot 0$; Moisture = ++ (6·2%)
Hardness at 48″ depth = 46 strokes, at bottom = 59 strokes
Percolation time at bottom = 140 min.
Organic matter = Moderate
Stones are *nil* in all the horizons.

NOTE :—(1) *Percolation time* is noted for seepage of 3″ length of a column of water vertically downwards.

(2) *Hardness* is counted in the number of strokes of the hammer of the Hardness Tester, to drive one inch of a cylinder with spherical bottom 1″ in diameter, into the soil.

(3) *Organic matter* High = soil giving vigorous reaction with hydrogen per-oxide 3%
Moderate = soil giving fairly good reaction with H_2O_2
Low = soil giving feeble reaction with H_2O_2
Nil = soil giving hardly any reaction with H_2O_2

(4) *Moisture* + soil just feeling cold to touch
++ moist but changes colour on wetting
+++ No change of colour on wetting (Field moisture capacity)
++++ Water logged.

Pit No. 2 : outside the fenced area (in control). Canopy ·5–·6, no operations done.

0″–14″ Greyish yellow sandy loam
$pH = 7 \cdot 0$; Moisture = + (3·5%)
Hardness at surface = 31 strokes
Percolation time at surface = 180 min.
Organic matter = High

14″–51″ Brownish yellow sandy loam
$pH = 5 \cdot 5$; Moisture ++ (4·3%)
Hardness at 24″ = 31 strokes
Percolation time at 24″ = 130 min.
Organic matter = Moderate to High

51″–72″ 2nd horizon continues
Brownish yellow sandy loam
$pH = 6 \cdot 5$; Moisture ++ (4·2%)
Hardness at 48″ = 45 strokes, at bottom = 22 strokes
Percolation time at bottom = 45 min.
Organic matter = Moderate.

Comments—Soil conditions in the two pits are more or less the same except that percolation at the bottom in the control area is quicker than in the treated area. This may be due to seepage of some clay in the treated area due to shrub cutting which gave more suspension of clay on the exposed surface which seeped down with rain-water. Shrub cutting has, however, not helped regeneration. Low moisture content in the subsoil is indicated in both the areas and this appears to be the main handicap. Therefore, trenching along, contour at right angles to the direction of regional drainage, to help seepage of run-off and thus addition to subsoil moisture, may help.

pH of the middle horizon is more acidic than the bottom, which shows extraction of bases by sal in the middle zone and is a very common occurrence in the sal forests. *pH* has, however, no bearing on the sal regeneration problem. Soil is non-calcareous and well supplied with organic matter and therefore, there is no likelihood of nutrient deficiency.

Pit No. 3 : was taken in U.P. Silviculturist's W.P. indicator line Experiment No. 11(a) where there is better whippy regeneration and there are some established coppice shoots also. Though soil conditions could not be completely examined due to lack of time (it was nearly 4 : 30 p.m. when I left Pit 2 and we had to go to Compart. 41 also), the soil conditions did not appear to differ from Pits 1 and 2. Cause of the existence of better regeneration can not be located yet without a more thorough examination.

Jaspur compartment 41—Sal type—A_2 (Champion's type), i.e., Dry Gangetic Alluvial sal.

Sal quality—II/III.

Two pits were taken in Jaspur compartment 41. Pit 1 was inside the Divisional Experimental Plot No. 13, where rains and winter shrub cutting was done. Hoeing was also done inside the fenced area in 1941 which brought in better whippy regeneration than in the control plot outside the fence, but it is not making good progress. Soil pits could only be casually seen (as we reached the area at 6 p.m. or so). However, it was seen that while the soil in the treated and fenced area is a sandy loam similar to the Jaspur compartment 47, the one outside the fence, without good regeneration has a sandy clay loam soil. It is possible that hoeing combined with open texture has brought in unestablished whippy regeneration in the treated area (Expt., Plot No. 13). But it is not making any progress due to subsoil moisture deficiency. Trend of *pH* of soil is the same as in the pits in compartment 47 (i.e., neutral in top-soil and slightly acidic in the subsoil). The actual *pH* values are given below.

	pH values of	
	Top-soil	Subsoil
Pit No. 1, inside fenced area Experimental Plot 13 ..	7·0	6·0
Pit No. 2, outside the fence (more clayey soil) ..	6·5	6·0

It may be noticed that the *pH* of the top-soil in the "no regeneration area" is more acidic than in the better regenerated area, and this goes against the theory of some workers who believe that acidic conditions in soil are conducive to regeneration.

Bhandarpani compartments 7a and 7b—In this area, in a fenced one acre plot in compartment 7a, regeneration has come up, while outside the fence it does not appear to grow well (perhaps due to browsing). In the fenced area in compartment 7a no operations are done (except fencing). The adjoining compartment 7b has good established sal poles.

Sal type—B_2 (Moist High level alluvial sal).
Sal quality—II/III.

Soil conditions—Three pits were taken, namely, Pit 1 inside the fenced one acre plot in compartment 7a, Pit 2 in the unfenced one acre plot in compartment 7a, and Pit 3 in the well regenerated area in the adjoining compartment 7b with established sal poles.

Pit No. 1: inside the fenced area where regeneration is coming up successfully.

0″–13″ greyish red clay loam
pH = 7·0 ; Moisture = ++ (21·1%)
Hardness at surface = 11 strokes
Percolation time at surface = 45 min.
Organic matter = High

13″–50″ Red clay loam, greezy to feel
pH = 6·5 ; Moisture = +++ (16·3%)
Hardness at 24″ = 11 strokes
Percolation time at 24″ depth = 124 min.
Organic matter = High to Moderate with depth

50″–72″ 2nd horizon continues
Red clay loam, greezy to feel
pH = 6·5 ; Moisture = +++ (22·5%)
Hardness at 48″ depth = , at bottom = 21 strokes
Percolation time at bottom = 196 min.
Organic matter = Moderate
No stones met throughout the profile.

Pit No. 2: outside the fenced area in Compart. 7a, in the one acre control plot.

0″–9″ Greyish red clay loam
pH = 7·0 ; Moisture = ++ (14·8%)
Hardness at surface = 30 strokes
Percolation time at surface = 101 min.
Organic matter = High

9″–50″ Red clay loam, greezy to feel
$pH = 6 \cdot 5$; Moisture = +++ (19·8%)
Hardness at 24″ depth = 25 strokes
Percolation time at 24″ depth = 102 min.
Organic matter = High to moderate with depth
No stones met throughout the profile

50″–72″ 2nd horizon continues
Red clay loam, greezy to feel
$pH = 6 \cdot 5$; Moisture = +++ (20·5%)
Hardness at 48″ = 22 strokes, at bottom = 23 strokes
Percolation time at bottom = 188 min.
No stones met throughout the profile

Pit No. 3 : in Compartment 7b with good established regeneration.

0″–10″ Greyish red clay loam
$pH = 7 \cdot 0$; Moisture = ++ (18·2 %)
Hardness at surface = 39 strokes
Percolation time at surface = 100 min.
Organic matter = High

10″–50″ Red clay loam, greezy to feel
$pH = 6 \cdot 0$; Moisture = +++ (19·6%)
Hardness at 24″ depth = 11 strokes
Percolation time at 24″ = 124 min.
Organic matter = High to Moderate with depth

50″–72″ 2nd horizon continues
Red clay loam, greezy to feel
$pH = 6 \cdot 5$; Moisture = +++ (20·9%)
Hardness at 48″ = 19 strokes ; bottom = 17 strokes
Percolation time at bottom = 132 min.
Organic matter = Moderate
No stones met throughout the profile.

Comments—Soil conditions in the three pits namely inside the fence which is well regenerated, outside the fence with poor regeneration and in compartment 7b with established sal poles, does not differ significantly. It shows that outside the fence browsing is perhaps the only adverse factor. If the area is fenced, unestablished whippy regeneration will shoot up.

Another important point is that the soil is a clay loam or clay but it is well supplied with moisture, perhaps due to under ground currents (a characteristic of the whole of Bhandarpani). It shows that provided regional drainage is good and soil is well supplied with moisture which does not stagnate, a clay loam or a clayey soil is not a disadvantage to regeneration. Here under conditions of favourable moisture clay does not dry up or harden up to offer resistance to the roots. This is confirmed by soil hardness tests in the field. It is seen in these soils that though percolation of water is slow, due evidently to the clayey nature of the soil, its hardness is not much. Over all conclusions, therefore, are that a clayey soil well supplied with subsoil moisture (at a level of field moisture capacity or moisture equivalent) but with no stagnation of water and in an area with free regional drainage, is not a disadvantage for regeneration, provided browsing is guarded against.

It may be added that the soil is non-calcareous and well supplied with organic matter and therefore nutrients.

Patkot compartments 2a and 2b—Of these, compartment 2a is a failed area and compartment 2b is regenerated. Unfortunately only half the pit could be dug in compartment 2a (it was very bouldery at a depth of two feet or so), and no pit at all could be dug in compartment 2b. Therefore, no comments could be made regarding the area except that moisture deficiency seems to be indicated in the failed area (visual observations only), and trenching across slope to absorb rain-water may help to increase subsoil moisture.

Pawalgarh compartment 1d—This area is situated on a ridge and has good regional drainage from SW. to NE. The Divisional Forest Officer, Ramnagar is starting hoeing experiments in order to obtain sal regeneration. A small area has been fenced and quadrats dug

up 6 inches, 9 inches, and 12 inches deep and the earth will again be filled into the quadrats. Trenches have also been made similar to the quadrats. Incidentally there will be more absorption of moisture in the dug up quadrats and trenches, though the experiment is primarily designed to see the effect of hoeing. South-west of the hoeing experimental plot, there is a small portion with sal and *bakli* (*Anogeissus latifolia*) mixed crop in the overwood, and here there is plenty of whippy unestablished regeneration. Two pits were taken, namely one in in the sal-*bakli* area with unestablished regeneration and the other just near the fenced area (*n.b.* there was no space for a pit inside the area and so the pit had to be taken just outside the western fence).

Sal *type*—B_3 type (Moist High Level Alluvial sal).

Sal quality—II/III.

Soil conditions

Pit No. 1 : in sal-*bakli* mixed area with whippy regeneration.

0″–6″ Greyish red clay loam, greezy to feel
pH = 7·0 ; Moisture ++ (12·3%)
Hardness at surface = 113 strokes
Percolation time at surface = 208 min.
Organic matter = High

6″–45″ Red clay, greezy to feel
pH = 6·5, Moisture = +++ (17·8%)
Hardness at 24″ = 46 strokes
Percolation time at 24″ = 158 min.
Organic matter = High

45″–72″ 2nd horizon continues
Red clay, greezy to feel
pH = 6·5 ; Moisture +++ (19·0%)
Hardness at 48″ = 53 strokes, at bottom = 45 strokes
Percolation time at bottom = 160 min.
Organic matter = High
No stones in any horizon.

Pit No. 2 : in the Divisional Experimental plot-hoeing experiment without any regeneration.

0″–9″ Greyish red sandy loam, greezy to feel
pH = 7·0 ; Moisture = ++ (13·3%)
Hardness at surface = 50 strokes
Percolation time at surface = 140 min.
Organic matter = High

9″–45″ Red clay loam, greezy to feel
pH = 6·0, Moisture = +++ (17·2%)
Hardness at 24″=32 strokes
Percolation time at 24″ = 181 min.
Organic matter = High

45″–72″ Red clay loam, greezy to feel
pH = 6 0 ; Moisture = +++ (16·0%)
Hardness at 48″ = 39 strokes, at bottom = 39 strokes
Percolation time at bottom = 176 min.
Organic matter = High
No stones in any horizon.

Comments—The soil in the sal-*bakli* plot with good regeneration (Pit 1) is more clayey and redder than the one in the problem area nearby. The former is at a higher level. The regional surface drainage in both the areas is free and in both of them the soil is well supplied with organic matter which penetrates to a good depth (high even at a depth of 6 inches). The redder soil in sal-*bakli* plot may be due to better aeration of the soil at higher level, but really the difference in colour is so little that this can not be said to account for the existence of regeneration here. In sal-*bakli* plot, it is again seen (as in Bhandarpani previously) that a clayey soil well supplied with underground moisture (but no stagnation of water) is not a disadvantage for regeneration of sal. Subsoil moisture in the area of Pit 2 (problem area) appears to be less than in the sal-*bakli* plot (though the difference is not very great). Hoeing

and trenching started by the D.F.O. is likely to add to the subsoil moisture apart from the aeration due to hoeing effect. This appears to be a very well designed, helpful and hopeful experiment.

It appears that a red soil (as in Pawalgarh, Bhandarpani and Barua) is favourable to regeneration of sal. Though these red soils are not likely to come under 'laterites' and these are perhaps 'red loams and clays', it will be worthwhile determining the SiO_2/R_2O_3 ratio and it will be done as limitations of time and staff permit. Surface hardness in the good regeneration area is more than in the area without regeneration. Therefore, surface hardening is not the cause of lack of regeneration. Soil is non-calcareous as in the other areas previously discussed. Soil is well supplied with humus which penetrates to a good depth and this is a helpful sign as soil will be rich in nutrients.

Barua compartment 2—This area is in Baur range of the Tarai and Bhabar Division. In this area fencing has helped to obtain good established regeneration. In all the areas taken for regeneration, felling (leaving standards) is completed in March and in the begining of winter and rains shrub cutting is done. Soon after felling in March the debris is collected in heaps and burnt. Area is fenced soon after. No other operations are done later. Regeneration, both coppice and *de novo* comes up as a result. There is no frost damage in this area.

Soil conditions

Pit No. 1: In sal natural regeneration area 1946, plot 24A.

0″–10″ Greyish red sandy loam
pH 6·5 ; Moisture = ++ (7·6%)
Hardness at surface = 12 strokes
Percolation time at surface = 53 min.
Organic matter = High

10″–45″ Red sandy loam
pH = 5·5 ; Moisture = +++
Hardness at 24″ depth = 12 strokes
Percolation time at 24″ depth = 90 min.
Organic matter = High to Moderate with depth

45″–72″ Red but slightly mottled with chocolate and having a sandy loam texture
pH = 5·5 ; Moisture = +++ (8·5%)
Hardness at 48″ = 15 strokes, at bottom = 17 strokes
Percolation time at the bottom = 80 min.
Organic matter = Moderate
No stones in any horizon in the soil.

Comments—The texture of the soil is sandy loam just as in Jaspur which is a problem area but the soil is redder in colour and the moisture content is higher. It is likely that the soil which is already of open texture and at the same time well supplied with moisture is helpful to regeneration. Redder colour of the soil shows that it is a red sandy loam type (not likely to be lateritic). However, it will be worthwhile ascertaining about the SiO_2/R_2O_3 ratio, which will be taken up as limitations of time and staff permit. Soil is non-calcareous. It is well supplied with organic matter and is therefore rich in nutrients.

Haldwani Forest Division – Horai compartments 4 and 7—These are in the Chakatta range. This area has lots of top-drying of sal and there is no regeneration. The area comes under Moribund sal. Two pits were taken, namely in compartment 7 in the NE. and in compartment 4 in the SW. In both these areas there is no regeneration at all.

Sal type—B_3 (Moist High level Alluvial sal).

Sal quality—I/II.

Soil conditions

Pit No. 1: in Compartment 7 on the NE. of the compartment boundary without any regeneration at all.

0″–11″ Greyish yellow sandy loam
$pH = 7 \cdot 5$; Moisture = + (4·7%)
Hardness at surface = 27 strokes
Percolation time at surface = 34 min.
Organic matter = High to Moderate with depth

11″–34″ Brownish yellow sandy loam
$pH = 5 \cdot 5$; Moisture = ++ (5·4%)
Hardness at 24″ depth = 9 strokes
Percolation time at 24″ depth = 24 min.
Organic matter = Moderate to Low with depth

34″–72″ Yellow and grey sand with dominant stones and boulders
$pH = 6 \cdot 0$, Moisture = ++ (6·3%)
Hardness at 48″ depth = 4 strokes, at bottom = 3 strokes
Percolation time = not taken due to stones but expected to be quick
Organic matter = Low to nil with depth.

Pit No. 2: in Compartment 4 on the SW. of the compartment boundary. There is no regeneration at all.

0″–18″ Greyish brown sandy loam
$pH = 7 \cdot 0$; Moisture = + (5·1%)
Hardness at surface = 30 strokes
Percolation time at surface = 30 min.
Organic matter = High to Moderate with depth

18″–33″ Brownish yellow sandy loam with few stones
$pH = 5 \cdot 5$; Moisture = ++ (6·1%)
Hardness at 24″ = 10 strokes
Percolation time at 24″ = 40 min.
Organic matter = Moderate

33″–72″ Yellow sandy soil with dominant stones and boulders
$pH = 6 \cdot 2$; Moisture = ++ (6·1%)
Hardness at 48″ = 3 strokes, at bottom = 3 strokes
Percolation time = could not be taken but expected very quick due to stones and boulders.

Comments—Soils suffer from moisture deficiency and have low organic matter content which has not got sufficient depth of penetration either. Soils, therefore, suffer from a deficiency of both moisture as well as nutrients (supplied by organic matter). Also due to sandy subsoil with excessive stones and boulders, rain-water perhaps does not stay in the subsoil. In this respect, conditions here are worse than even in Jaspur (in Ramnagar division). It is very possible that mortality of regeneration here takes place more during drought following rains rather than in the rainy months, but this point needs to be ascertained. Soil around pit 2 in compartment 4 is better placed with regard to organic matter and this is reflected in its having a higher percolation time, i.e., better moisture retentivity. Comparing these pits (and also Jaspur) with better regenerated areas of Bhandarpani and Pawalgarh, it is seen that open texture of soil though ordinarily helpful will not help regeneration if there is moisture deficiency, because the latter becomes a limiting factor. Barua in Tarai and Bhabar division is best placed with regard to both texture and moisture. In Bhandarpani (Ramnagar division), however, clayey texture is much over balanced by the advantage of underground moisture supply, and this shows that clayey nature of soil will not become a limiting factor provided moisture supply is adequate and water does not stagnate. Soils of Horai (compartments 4 and 7 only are referred to) also appear to be poorly supplied with organic matter and therefore should be low in nutrients. These soils are non-calcareous.

Sela compartments 6 and 5b—These are more or less west of Horai compartments 7 and 4, with Sukhi block in between. Conditions of regeneration are supposed to be much better here than in Horai. Sela compartment 5b in the north is regenerated inside the fence and has 1–4 feet high whippy (unestablished) seedlings. Dry fellings are being done now in 1953 after about 5–6 years and winter and rains shrub cutting is perhaps annually done (informed by forester). Sela compartment 6 on the south has no regeneration.

Sal type—B_3 (Moist High level Alluvial sal).

Sal quality—I/II.

Soil conditions

Pit No. 1: in Compartment 6, without regeneration.

0″–14″ Greyish brown sandy loam
pH = 7·0 ; Moisture = + (7·1%)
Hardness at surface = 30 strokes
Percolation time at surface = 57 min.
Organic matter = High

14″–48″ Reddish brown sandy loam
pH = 5·0 ; Moisture = ++ (7·6%)
Hardness at 24″ = 14 strokes
Percolation time at 24″ = 37 min.
Organic matter = Moderate

48″–72″ Yellowish red with chocolatish mottle, Sandy loam
pH = 5·0 ; Moisture = +++ (8·1%)
Hardness at 48″ depth = 11 strokes, at bottom = 18 strokes
Percolation time at bottom = 51 min.
Organic matter = Moderate
No stones in any of the horizons.

Pit No. 2: in Compartment 5b inside the fence, with whippy (unestablished regeneration 12″–48″ high).

0″–11″ Brownish grey sandy loam
pH = 7·0 ; Moisture = ++ (6·6%)
Hardness at surface = 13 strokes
Percolation time at surface = 30 min.
Organic matter = High

11″–49″ Reddish brown sandy loam, no stones
pH = 6·0 ; Moisture = +++ (9·8%)
Hardness at 24″ = 5 strokes
Percolation time at 24″ = 25 min.
Organic matter = High to Moderate with depth

49″–72″ Yellowish red sandy loam with frequent stones
pH = 6·0 ; Moisture = +++ (9·4%)
Hardness at 48″ depth = 9 strokes, bottom = 5 strokes
Percolation time at 48″ = 45 min. (bottom not taken due to stones)
Organic matter = Moderate.

Comments—Compared to Horai, the soil in Sela is better supplied with natural moisture. The subsoil is not so sandy and stony and should, therefore, be more retentive of moisture. Soil is redder in colour which is generally indicative of better soil conditions for sal regeneration. Comparing, however, the soil conditions in Pit No. 1 (compartment 6, no regeneration) and Pit No. 2 (compartment 5b with regeneration) there is more moisture in the subsoil of the latter which appears to be an advantage. Otherwise the soil conditions do not appear generally different. Judging from the soil conditions on the whole, it appears that if the area in compartment 6 is fenced and other treatments given as in compartment 5b, regeneration is likely to come up. Soil in both the areas appears to be moderately well supplied with organic matter and, therefore, should have good nutrient value. Soil is non-calcareous.

Lakhmanmandi compartments 5 and 4—In compartment 5 which is just below Sunmanthapla plateaux, shrub cutting and hoeing was done in March 1952 and the area was fenced. As a result, the regeneration of 1951 seed year came up and developed into good whippy (unestablished) shoots 12 to 36 inches high. March shrub cutting and hoeing was done in 1952. Pit No. 1 was taken inside the fenced divisional experimental plot of this compartment 5. Pit No. 2 was taken in compartment 4 (south of compartment 5) in the preservation plot where there is very little regeneration. Pit No. 3 was taken further south-west of the preservation plot in an area where shrub cutting is done annually for the last 15 years and burning was done continuously from 1948 to 1951. Regeneration in this area is better than

that in the preservation plot and some whippy (unestablished) regeneration is also there, though doing miserably. As the area is not fenced it is possible that browsing is also a factor. Regeneration in the fenced plots in compartment 4 are the best of the lot, next is the area in compartment 5 with operations just described and worst of all is the preservation plot in this compartment.

Sal type—B_3 (Moist High level Alluvial sal).

Sal quality—I/II.

Soil conditions

Pit No. 1: in Compartment 5, Divisional Experimental Plot, shrub cutting and hoeing done, resulting in good whippy (unestablished) regeneration 12″–36″ high.

0″–14″ Reddish grey (chocolate) sandy loam, with few small and medium stones
$pH = 7 \cdot 0$; Moisture = ++ (11·5%)
Hardness at surface = 23 strokes
Percolation time at surface = 26 min.
Organic matter = High

14″–52″ Dark reddish brown sandy loam, with frequent stones and boulders after 36″ depth
$pH = 6 \cdot 0$; Moisture = +++ (11·4%)
Hardness at 24″ = 6 strokes
Percolation time at 24″ depth = 20 min.
Organic matter = High

52″–72″ Reddish brown sandy loam with frequent stones and boulders, getting excessive with depth
$pH = 5 \cdot 5$; Moisture = +++ (10·0%, less than above due to stoniness)
Hardness at 48″–3 strokes, bottom = 3 strokes
Percolation time = could not be taken due to stony nature
Organic matter = High to Moderate with depth.

Pit No. 2: in Compartment 4, preservation plot.

0″–15″ Reddish grey (chocolate) sandy loam, with few stones
$pH = 7 \cdot 0$; Moisture = ++ (12·4%)
Hardness at surface = 17 strokes
Percolation time at surface = 100 min.
Organic matter = High

15″–40″ Dark Reddish brown sandy loam, with frequent stones and boulders after 36″ depth
$pH = 6 \cdot 0$; Moisture = +++ (12·7%)
Hardness at 24″ depth = 9 strokes
Percolation time at 24″ depth = 20 min.
Organic matter = Moderate

40″–72″ Reddish brown sandy loam, with frequent stones and boulders getting excessive with depth
$pH = 5 \cdot 5$; Moisture = +++ (10·6%)
Hardness at 48″ = 5 strokes, bottom = not taken
Percolation = not taken due to stoniness
Organic matter = Moderate.

Pit No. 3: in Compartment 4, south-west of the Preservation Plot; burning done from 1948 to 1951 and shrub cutting done for the last fifteen years.

0″–16″ Reddish grey (chocolate) sandy loam, with few gravel
$pH = 7 \cdot 0$; Moisture = ++ (11·0%)
Hardness at surface = 18 strokes
Percolation time at surface = 21 min.
Organic matter = High

16″–37″ Dark Reddish brown sandy loam, with few gravel and stones
$pH = 6 \cdot 0$; Moisture = +++ (10·5%)
Hardness at 24″ depth = 6 strokes
Percolation time at 24″ depth = 19 min.
Organic matter = Moderate

37″–72″ Reddish brown sandy loam, with frequent gravel and stones getting dominant with depth
$pH = 5 \cdot 5$; Moisture = +++ (9·2%, stony soil)
Hardness at 48″ depth = 6 strokes
Percolation time = not taken due to stones
Organic matter = Moderate.

Comments—The soil characteristics in the three pits are more or less the same except that in Pit 2 (Preservation plot in compartment 4) the last horizon is less dark and perhaps

has less organic matter. Also in this Preservation Plot the surface layer of soil has high percolation time as compared to Pits 1 and 3 where shrub cutting has been done and in Pit 3 hoeing also was done. Judging from the soil conditions, if the areas near Pit 2 (Preservation Plot) and Pit 3 (shrub cutting) are fenced, regeneration should come up.

It is worthy to note that some teak plantations in the northern portions of Sela and in the Lakhmanmandi block have done very well and have given high quality teak (AIQ II). It seems that a red sandy loam, in the areas with none or little frost damage as in Sela and Lakhmanmandi and with soil well supplied with organic matter and under-ground moisture, are favourable for teak and perhaps more so than sal.

Sunmanthapla compartment 1 (fenced)—Here regeneration is coming up very well inside the fence and there are whippy (unestablished) seedlings 3–5 feet high and some even 6–7 feet high here and there. Winter shrub cutting is done and perhaps in the beginning both winter and rains shrub cutting was done. Only one pit was taken for comparison with the soils of the areas with the problem of regeneration.

Sal type—B_3 (Moist High level Alluvial sal).

Sal quality—I.

Soil conditions

Pit No. 1 : in Compartment 1, fenced and regenerated with winter shrub cutting done.

0″–16″ Reddish grey (chocolate) sandy loam, with few stones and boulders
$pH = 7 \cdot 5$; Moisture = ++ (11·4%)
Hardness at surface = 22 strokes
Percolation time at surface = 132 min.
Organic matter = High

16″–54″ Dark Reddish brown (chocolate) sandy loam, with few to frequent stones and boulders
$pH = 6 \cdot 0$; Moisture = +++ (11·6%)
Hardness at 24″ depth = 13 strokes
Percolation time at 24″ depth = 112 min.
Organic matter = High to Moderate with depth

54″–72″ Reddish brown sandy clay loam, with frequent stones and boulders
$pH = 6 \cdot 0$; Moisture = +++ (11·5%)
Hardness at 48″ depth = 13 strokes
Percolation time = not taken due to stones
Organic matter = Moderate.

Comments—The soil is a red sandy loam getting sandy clay loam with depth with some stones and boulders in the subsoil. It is, therefore, well aerated. At the same time the soil is well supplied with subsoil moisture being a plateaux topography by the hill-side. Soil is well supplied with organic matter and, therefore, rich in nutrients. All these factors, i.e., favourable conditions of aeration and moisture supply and good content of organic matter and nutrients are conducive to high quality sal and good regeneration.

Duan compartments 1 and 2 – near Tanakpur, in Sarda range—Compartment 1 which is situated in the north and is by the side of an outer Himalayan Hill Range has some regeneration with whippy (unestablished) seedlings 24–36 inches high at a number of places. Compartment 2, however, which is situated further south has poor or no regeneration. There is some top drying of sal also in both these areas. Two Pits were taken namely, Pit 1 in Compartment 1 with fairly good regeneration and Pit 2 in Compartment 2 where there is practically no regeneration.

Sal type—B_3 (Moist High level Alluvial sal).

Sal quality—I.

Soil conditions

Pit No. 1: in Compartment 1, with fairly good regeneration.

0″–15″ Reddish grey (chocolate) sandy loam
$pH = 7 \cdot 0$; Moisture = ++ (7·7%)
Hardness at surface = 31 strokes
Percolation time at surface = 108 min.
Organic matter = High

15″–51″ Dark reddish brown sandy loam
$pH = 5 \cdot 0$; Moisture = +++ (9·3%)
Hardness at 24″ = 16 strokes
Percolation time at 24″ depth = 132 min.
Organic matter = High to Moderate

51″–72″ Reddish brown sandy loam with few small stones
$pH = 5 \cdot 0$; Moisture = +++ (11·8%)
Hardness at 48″ = 24 strokes, at bottom = 22 strokes
Percolation time at bottom = 132 min.
Organic matter = High to Moderate.

Pit No. 2: in Compartment 2 with extremely poor regeneration hardly a couple of miserable looking seedlings here and there.

0″–10″ Yellowish grey sandy loam, with few gravel
$pH = 6 \cdot 5$; Moisture = + (6·4%)
Hardness at surface = 16 strokes
Percolation time at surface = 92 min.
Organic matter = High to Moderate with depth

10″–34″ Brownish yellow with yellow mottle sandy loam, with few gravel and small stones
$pH = 5 \cdot 0$; Moisture = ++ (7·4%)
Hardness at 24″ depth = 16 strokes
Percolation time at 24″ depth = 72 min.
Organic matter = Moderate to Low with depth

34″–72″ Brownish yellow sandy, with frequent stones and boulders getting excessive below 48″ depth
$pH = 5 \cdot 5$; Moisture = ++ (6·5%)
Hardness at 48″ depth = 5 strokes
Percolation time at bottom = not taken due to excessive stones, but expected low
Organic matter = Low.

Comments—Pit No. 1 in Compartment 1 shows that the soil is well supplied with moisture and organic matter (to a good depth). Soil being a sandy loam should be well aerated. If this area is fenced, shrub cutting done and if possible trenches made across the slope to arrest rain-water and thus further increase moisture in the subsoil, it should be conducive to good regeneration. Pit 2 in Compartment 2 shows, however, a very poor soil with some organic matter only in the top layer but poor content of organic matter in the subsoil. Retention of moisture is poor due to stony and bouldery subsoil. Perhaps regeneration is dying not only during rains as Hole may have surmised but also during post rainy period due to drought. Area is not likely to respond to treatments such as trenching and shrub cutting for bringing in regeneration.

General discussion—A general soil survey gives the following indications with regard to the bearing of soil conditions on the problem of regeneration of sal.

1. The problem of sal regeneration is not only a problem of soil aeration but also a problem of adequate supply of moisture to the sal plants in all stages of growth (without water logging or stagnation of water). In other words the drainage conditions should be such that water remains in the subsoil at a level of "moisture equivalent" or "field moisture capacity", above which there is danger of water logging. On the other hand if the soil moisture falls below the limit of "wilting coefficient" there will be mortality of regeneration due to moisture deficiency. The latter will occur during the post rainy months in some of the problem areas, where moisture deficiency is indicated. Instances of such areas are Horai compartments 7 and 4 in the Haldwani division and Jaspur compartment 47 in the Ramnagar division.

2. A soil profile having a red or reddish brown sandy loam well supplied with subsoil moisture (but no water logging) is most conducive to good sal regeneration and also perhaps good quality sal. Instances are Barua in the Tarai and Bhabar division and Sunmanthapla in the Haldwani division.

3. A red clay loam either in the top-soil or the subsoil, provided it is well supplied with subsoil moisture (which does not stagnate) is not a disadvantage to sal regeneration. The hardness of the soil does not go high in such a soil because it does not dry up due to natural subsoil moisture. Provided browsing is guarded against, such an area will give good regeneration. As an instance of such areas may be taken Bhandarpani compartments 7a and 7b.

4. Even if the soil is a sandy loam and consequently well aerated, moisture deficiency in soil may become a limiting factor with regard to regeneration. (a) Extreme conditions will be found where the subsoil has lots of boulders and the subsoil in itself happens to be sandy which further exaggerate the drought conditions as in Haldwani compartments 7 and 4. In such areas there will be mortality of regeneration most likely due to soil drought during the post rainy period. It may be worthwhile if the Provincial Silviculturist or the Divisional staff try to note the extent of mortality of regeneration during rains as well as the post rainy period in such areas. There will also be top drying of sal trees in such areas due to similar reasons. (b) Effect of drought may be milder if the subsoil is not sandy but happens to be a sandy loam with better moisture retentivity and the boulders or stones in the subsoil are at some depth say 6 feet of so. The retention of moisture will be better in such cases as for example in Jaspur compartment 47. In such an area there may be some regeneration but it will not make much progress because the soil moisture is not enough to cope with the transpiration by the plants. Top drying of sal trees will, of course, occur due to the same reason.

5. Considering the Ramnagar and the Haldwani divisions and particularly the latter, it is found that in general as we go from north to south the conditions of regeneration get worse and also the problem of top drying of sal intensifies. Conditions of moisture supply seem to have a close bearing on both these aspects of the growth of sal. In the north particularly at the foot of the hills (e.g., Lakhmanmandi compartment 5) and more especially in a plateaux topography by the hill-side (e.g., in Sunmanthapla) soil seems to be better supplied with moisture perhaps due to underground hill springs, visible or latent. In the areas with foot-hill topography the subsoil moisture will also be increased due to rain-water flowing down the hill and getting absorbed in the subsoil. Spring moisture is not an uncommon occurrence on the hills and hill-sides. As we go further south to Horai (Haldwani division), subsoil moisture decreases and this is detrimental to regeneration. Chances of top drying of standing sal trees are also increased. There is of course an exception in case of Sela block which though in the south of Lakhmanmandi has regeneration in it, while in parts of Lakhmanmandi which is in the north there is lack of regeneration. Perhaps if these southern portions of Lakhmanmandi are fenced, soil working done and if possible trenching (at right angles to slope) done, regeneration will come up. With the data at our disposal no definite light can be thrown on this point and need for further observation and investigation (by Division or Provincial Silva U.P.) is indicated.

Helping hand of subsoil hill spring moisture is very visible in Bhandarpani compartments 7a and 7b (Ramnagar division), where inspite of a clay loam or a clayey soil, sal regeneration comes up happily on enclosing the areas with deer proof fence. The sal is Champion's B_3 type (Moist High level Alluvial sal) which is known to have regeneration problem. But Bhandarpani, as its name indicates, is full of subsoil springs and subsoil seems to have moisture content from 15–20 % which is in the region of 'moisture equivalent' or the 'field moisture capacity' for soil of this texture. Spring moisture gives good moisture supply to plants without stagnation and, therefore, there is good regeneration. Good moisture supply in the subsoil is

also seen in Barua and also in the good regeneration area in Pawalgarh compartment 1d. On the other hand in the areas with the problem of regeneration as in Jaspur (Ramnagar division) and Horai (Haldwani division), moisture deficiency is indicated. For the latter areas, trenching at right angles to the direction of regional drainage may help in arresting rain-water and adding to subsoil moisture supply.

6. It was previously stated that a red or a reddish brown soil in general have good natural regeneration (see para 2). Question naturally arises whether the nature of this red of ferruginous looking soil is conducive to regeneration. I am inclined to think that the nature of this red soil has no correlation to regeneration. Generally red or reddish brown soils are formed under conditions of good aeration and adequate but not excessive supply of moisture because these are conducive to the formation of highly hydrated oxides of iron which give red colour to the soil. Red colour may not necessarily be due to high amount of iron oxide but its high hydration. As far as good regeneration is concerned, it is the environmental factors of good aeration and adequate moisture which are really conducive to good regeneration. Thus red colour of soil and good regeneration are a result of the same set of environmental circumstances and may not be inter-dependent on each other. Of course red colour, due to reasons given above, is indicative of favourable conditions of site and soil even though not an inherent characteristic of a favourable soil. In other words, all the soils which are not red cannot be taken as bad soils. If favourable conditions of good soil aeration and adequate moisture are obtained, regeneration should come up.

7. In a soil well supplied with moisture it is found that even if it is clayey as in Bhandarpani, the hardness is low even though percolation time for water is high evidently due to clayey nature. It shows that clayey soil, with good moisture content in the region of 'moisture equivalent' or 'field moisture capacity', will not offer resistance to the penetration of roots into the soil. If, however, moisture in such a soil gets deficient, it will become a limiting factor firstly due to lack of water and secondly by making the soil hard and resistant to root penetration.

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THE GRASSES OF MADHYA PRADESH

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SUMMARY

In this paper a general description has been given of all the grasses collected from Mandla, Chanda, Bastar and a few other districts of Madhya Pradesh along with their ecology and economic importance.

INTRODUCTION

The main means of livelihood in our country is agriculture, which has mostly depended till now on cattle power. It will continue to do so for a very long time in future as we are very short of materials necessary for mechanization. The percentage of vegetarians in India is quite high, and the only nutritive ingredient in their food is milk or its products. Thus, improvement of our cattle-stock is absolutely essential. The main feed of the cattle is grass and the poor condition of the cattle stock of our country is due mostly to our general ignorance about grasses and the consequent poor management of the grasslands.

Most of our Development Officers want information about different grasses and the availability of their seeds.

The Forest Department in this State realizes a revenue of about 20 lacs of rupees from grazing licenses when the rates are very low and the farmer is allowed to graze 4 cattle free per plough and 4 at concessional rates. The total cattle population of this State numbers more than 40 lacs, and it is estimated that more than 50% of it grazes in Reserve forest. Nair and Sagreiya had tried to study the grazing problems of Madhya Pradesh (1941) and it has always been felt that detailed research work is necessary on this subject. Closure to grazing, fire protection and thinning are three important operations applied for the improvement of our forests. What effects do each of them make separately and also collectively on the growth of grasses is an important subject requiring intensive investigation.

Apart from the fodder species there are many kinds of grasses which are of great commercial importance. For example *Sum* or *Sabai-grass* (*Eulaliopsis binnata*) is an important raw material for manufacturing paper. Once, an enquiry was made from all the divisions about the availability of this grass but a correct estimate could not be made because the subordinate staff could not identify the grass. Local names of the grasses vary from place to place and are of little use in identifying them. There are some grasses like *Kans* and *Mawai* (Photo No. 1) which are troublesome weeds in the fields ; some which are preventing soil wash from the barren hills ; yet others provide food for the poor in times of famine, and so on. In forestry grasses play an important role. When we raise teak or other plantations it is the grasses which have to be weeded out, and it is *Imperata* which is responsible for the failure of many plantations. The study of the grass flora of a locality may help us in selecting suitable sites for teak or other plantations.

The importance of grasses in the economy of our country is very great. In Madhya Pradesh their study has a special significance. There are exhaustive floras for Bihar, Madras, Bombay and Uttar Pradesh. There is none for Madhya Pradesh and the identification of grasses, specially with the help of local names, is impossible. In 1912 Graham, a former economic Botanist to the Government of Madhya Pradesh who had made some study of grasses brought out a small pocket book entitled, "List of grasses and Sedges found in Nagpur and

Telankheri farms". This was of some use to the students of Agriculture college but was of no use either to them when they passed out and went to other districts or to foresters. Since then, most of the names of grasses have changed and the booklet now hardly serves any useful purpose. After Graham, no systematic study of grasses had been done. Until it was started by me in 1948 ; since then collection has been made by me mostly from the districts Chanda, Mandla and Bastar and partly from others like Nagpur, Betul, Seoni and Raipur. The object of this paper is to bring to light the large number of grasses which are found in this State, along with their ecology and economic importance. In order to economize space only the characteristic features have been given ; other details have been avoided. Short keys have been given for groups of species, only for those genera which contain many species. It is hoped that this paper will serve some useful purpose to foresters and agriculturists. There are about half a dozen of species which were not found by me in the above three districts but which have been described in Graham's book. These are mostly found in the western and drier districts of the State and they have been included here in order to make this paper more useful for the whole of Madhya Pradesh.

The total number of species described by Graham in his pocket book was 120, while in this paper this number has increased by 101 species and several varieties. This large addition is mostly due to the collection having been done over a larger area and from more interior localities. The description of species is arranged alphabatically. The serial numbers were given on the specimen sheets, and, on account of the changes in the identification of some grasses, the number has been disturbed ; it now indicates only the number of the specimen sheets numbers.

Abbreviations—infl., inflr., inflorescence ; spkt., spikelet ; spkts., spikelets ; flrs., flowers sp., spp., species.

I. ALLOTEROPSIS Presl.

Leaves ovate to linear ; infl. whorled or digitate ; glume ii, fringed with hairs, spkts. very shortly awned.

1. *A. cimicina* Stapf. Common.

A medium-sized hairy grass 6″–2′ high, with ovate to ovate lanceolate leaves ; spkt. dorsally compressed, ovate, fringed with dense pink hairs. Awn ·2″–·04″.

Perennial ; a very common sp. in waste-land and compounds on sandy loam soil ; fair fodder. Flrs. July–August.

2. *A. semialata* (H. K. F.) Hitch. Mandla and Bastar.

A tall grass 2′–5′ high with bulbous roots, covered with white woolly hairs ; the bulbs of each year line up slantingly ; leaves long linear ; spkt. 2″ long and fringed with pink hairs.

Perennial ; common at higher altitudes in sal forests of Bastar and Mandla ; new leaves and inflr. come out after the forest fires in April–July. Fair fodder.

II. AMPHILOPHIS Nash.

Inflr. consists of digitate spikes or a panicle with short primary branches. Pedicels and joints with longitudinal and translucent groove. Rachis disarticulating ; spkts. in pairs, one pedicelled, the other sessile, sometimes pitted on the outside.

3. *A. glabra* Stapf. Common.

A medium-sized grass 1′–3′ high ; panicle branches with axillary ciliate tubercles and much shorter than the rachis, glume (i) 2 to 3 pitted and not hairy ; leaves mostly clustered at the base.

Perennial ; common in rocky places. A good fodder. Flrs. October–December.

4. *A. ischaemum* Nash ; *Tamb*, *Bari-kandi* (Hindi), *Duma-tokar* (Madia).

A very tall grass up to 6′ high with villous nodes and primary axis of the panicle up to 10″ long. Glume i, generally without pits.

Perennial ; generally found along block boundaries and *nallahs*, flrs. October–December, also in April–May after summer fires followed by a few showers. A fair fodder when green ; used for making baskets.

5. *A. pertusa* Stapf. *Malhar*, *Chelikal* (Hindi). Common.

A small tufted decumbent grass, 1′–3′ high, panicle branches with ciliate tubercles but much longer than the primary rachis.

Perennial ; grows on variety of soils ; common on bunds of fields, roadsides, etc. A good fodder grass. Flrs. October–December and also March–June.

III. ANDROPOGON L.

Spikes geminate, covered by a spathe. Spikelets in pairs one sessile, the other pedicelled on articulating rachis.

6. *A. ascinodis* C. B. d. Bastar and Mandla.

A tall grass 3′ – 6′ high, often copper coloured. Panicles 2 to 3 with a slender peduncle 1″–2·5″ long, coming out at most of the nodes.

Perennial ; common in forest blanks in hilly areas. A good fodder. Flrs. October–December.

7. *Eremopogon foveolatus* Stapf.

8. *A. pumilus* Roxb. ; *Dewartan* (Hindi). Chanda, Mandla and Bastar.

A small grass 6″–12″ high, generally copper coloured ; spikes thick ·5″–·8″ long.

Perennial ; a fair fodder, found on alluvium and in hilly areas. Flrs. October–December.

IV. APLUDA L.

Tall leafy grasses, spike reduced to three spkts. with a bulbous base on a slender peduncle in spathaceous panicles.

10. *A. aristata* Linn. ; *ponai* (Hindi), *Moochh-khad* (Halbi). Common.

A very tall grass up to 7′ high ; leaves linear up to 18″ × 1″, narrowed and subpetiolate at the base. Spkts. curved.

Perennial ; not liked by cattle. Grows sporadically in hills, plantations on slopes and on bunds of fields in Mandla. Flrs. October–December.

11. *A. mutica* Linn. ; *ponai* (Hindi). Common.

A somewhat smaller grass 2′–4′ high with geniculate, delicate stems.

Perennial ; found mostly on black cotton soil in wet places under medium shade. Flrs. September–November.

V. APOCOPSIS Nees.

Raceme terminal solitary or 2-nate, spkts. two flowered, closely secund, compressed, accompanied by the pedicel of the suppressed pedicelled spikelet. Callus brown hairy.

12. *A. paleacea* (Trin.) Hocher ; *Nad-Ronda* (Madia). Mandla and Bastar.

A small grass 6″–12″ high, leaves narrowly lanceolate 0·5″–2″ long. Awn short or O.

Perennial ; common in the sal forest blanks marked out by its brown spikes after forest fires in April–May. A good fodder grass. Flrs. April–September.

13. *A. wightii* Nees. Mandla, Chanda and Bastar.

A decumbent grass 6″–18″ high, spikes brown with 0·75″ to 1″ long awn.

Annual ; found in wet places on poor soil, along rocky *nallahs*, etc. Flrs. October–January.

VI. ARISTIDA L.

Inflr. an effuse or contracted panicle. Spkts. one flowered with trifurcate awn ; glumes wrapping round the fruit tighty. All the spp. useless as fodder.

14. *A. cumingina* Trin. Common.

Small tufted grass 3″–9″ high, gregarious, soft with thin leaves and rachis generally purplish. Spkt. 0·1″ long.

Annual ; common on wet, sandy lateritic, gravelly and poor soils. Flrs. October–November.

Two varieties are commonly seen in the field, one with a close and comparatively rigid panicle and the other with an effuse and lax panicle.

15. *A. depressa* Retz. ; *Sikronda* (Halbi). Common in Chanda.

A small tufted grass with decumbent lax stems and sparsely spaced spkts. 0·2″–0·3″ long without the awn.

Annual ; found on sandy soil in Dhaba range. Flrs. November–December.

16. *A. funiculata* Trin. and Rupr. Chanda.

A very beautiful, laxly branched grass ; spkt. 0·5″ long without the awn, pale yellow ; awn with 3 slender branches 1–1·5″ long.

Annual ; on sandy soil in Dhaba range. Flrs. September–November.

17. *A. hystrix* Linn. Chanda, rare.

A thick and tufted small grass 5″–12″ high with a beautiful stiff thyrsoid panicle.

Annual ; collected from Chanda on sandy soil. Flrs. October–December.

18. *A. redacta* Stapf. ; *Burgi* (Hindi). Chanda, Mandla.

A slender tufted grass 6″–2′ high with lax purplish panicle. Lateral branches of the awn very short or O.

Annual ; common on light soil in open forests. Flrs. September–October.

19. *A. setacea* Retz. ; *Burgi, Kusara* (Hindi). Mandla, Chanda.

The tallest sp. in the genus 2′–3′ high ; panicle 6″–15″ long contracted, inclined, feathery with rather close clusters of branches ; spkts. 0·4″–0·7″ long without the awn.

Perennial ; an obnoxious weed on sandy and poor soil ; the awns pierce through clothes as those of *sukul*. Very common in Dhaba range. After the dispersal of seeds the infr. is used for brooms locally. Flrs. September–February.

VII. ARTHRAXON Beau.

Infl. digitate, all spkts. alike thin, long awned, leaves generally short, lanceolate to ovate deeply cordate. Most of the spp., useless as fodder.

A. Pedicelled, spkts. present *lancifolius, echinatus, lanceolatus, villosus, rudis.*

B. Only pedicel of the pedicelled spkts. present *hispidus.*

C. Not even the pedicel of the pedicelled spkt. present *quartinianus.*

20. *A. echinatus* Hochst ; Bastar, rare.

Lower glume of the spkt. covered with thick pointed tubercles in rows.

Perennial ; collected from Tirathgarh among rocks (etc., 2000′). Flrs. October–November.

21. *A. hispidus* Makino ; *Madia* (Hikka). Bastar.

Culmus 10″–20″ high, nerves of clume (i) hispid and margins of glume (ii) hispid.

Annual ; under shade of trees or among tall grasses on well-drained soil. Flrs. October–December.

22. *A. lancefolius,* Hochst ; *Konda-ronda* (Halbi), *Lotna* (Hindi). Common.

A very small weak branchy grass 6″–9″ high with whitish to light pink hairy panicle ; leaves up to 1·7″ × ·47″.

Annual ; common on hill cuttings and on sandy soil, under medium to full shade ; comes up on old walls and roofs during the rains. Flrs. August–September.

One specimen similar in appearance and identified as above at Sibpur has been collected from Bastar. It has no pedicelled spikelet and is easily distinguishable in the field. It requires further investigation.

23. *A. lanceolatus* Hochst ; Mandla, Bastar.

A medium-sized grass 2′–3′ high. Root-stock and lowest one or 2 leaf-sheaths densely *tomentose.*

Perennial ; on well-drained soil along *nallahs* and hill slopes. Flrs. November–March.

24. *A. quartinianus* Nash ; *Kakrya, Basin, Laplania* (Hindi), *Wader-watch* (Madia). Common.

A gregarious slender grass 9″–20″ high ; spkts. long cylindrical, 0·1-0·15″ long, minutely scaberulous ; joints finely ciliate on one side only ; spkts. sometimes purplish.

Annual ; found along hill slopes on lateritic soil during the rainy season. Flrs. October–November.

224. *A rudis* Hochst.

An erect tufted grass up to about 12″ in height ; lower glume of sessile spkts. 0·22″ long with two keels ; keel margins with double rows of pinkish, tubercled teeth gradually converted into spinules at the apex ; the middle portion of the glume villous with very minute and small whitish hairs. Pedicelled spkts. fully developed with 3 ciliate glumes. Joint compressed. 18″ long and ciliate on two sides. Leaves lanceolate sessile with sparse tubercled white hairs on the margins in the lower half.

Perennial ; found on barren but moist hill-tops in the cracks of rocks.

25. *A. villosus* C. E. C. Fischer ; Rare, Bastar.

Back of glume (i) of sessile spkts. villous ; collected from Dogaon Dodi, Makdi block specimen spoilt.

Perennial ; in forest blanks along ditches.

VIII. ARUNDINELLA Raddi.

Panicle not decompound, two persistent glumes are left behind after dispersal of fruit. Spkts. awned sometimes with 2 setae. Generally not good fodder.

A. Panicle very much crowded, cylindrical—*bengalensis.*

B. Panicle effuse :—

(*i*) Upper lemma with 2 apical setae along with the awn-*setosa,*

(*ii*) Upper lemma with one awn only *metzii, nepalensis, pumila.*

31. *A. bengalensis* Druce. Mandla, Bastar.

Robust grass 2′–3′ high with a woody creeping rhizome ; sheaths with tubercled hairs.

Perennial ; in marshes near *nallahs* on sandy loam soil. Flrs. August–November.

27. *A. metzii* Hochst. Bastar (2000′), etc.

A small grass 3″–20″ high ; upper and lower glumes unequal, nearly smooth ; lower 0·06″–0·1″ upper 0·1″–0·13″ ; awn 0·1″–0·11″ long.

Annual ; rare ; under medium shade in wet places. Flrs. October–November.

28. *A. nepalensis* Trim. Mandla, Bastar.

A tufted gregarious grass 6″–20″ high, panicle effuse ; spikelets scaberulous, often purple, sheath more than 0·12″ long.

Perennial ; found along ditches in open (ele. above 1500′). Flrs. September–November.

29. *A. pumila* Steud. Bastar (2000′) rare.

A very weak grass up to 20″ high with minute and distant spkts. ; upper lemma 0·03″–0·04″ long.

Annual ; under medium to full shade on laterite and poor soil. Flrs. October–November.

30. *A. setosa* Trin. ; *Sidi ronda* (Halbi). Mandla, Bastar (1500′).

Tall grass up to 5′ high with thick stoloniferous roots ; leaves involute, setaceous acuminate. Panicle up to 9″ long, green grey to purple.

Perennial ; on gravelly soil on hills and in the poor forest. Flrs. October–November.

IX. ARUNDO L.

2 glumes left on the panicle after dispersal of fruits ; rachis slightly hairy ; flowering glumes dorsally hairy.

32. *A. donax* Linn ; *Bahya Danda* (Halbi). Chanda, Mandla, Bastar.

A tall reed up to 10′ high. Panicle dense oblong or thyrsoid leaves amplexicaul ; paleas hairy.

Perennial ; generally planted in gardens ; its roots are said to be used against dogbite

X. BOTHRIOCHLOA

4a. *B. intermedia* A. Cam.

Deserted village site of Hari Marka, Narainpur range. A tall perennial grass with ·2″–·25″ thick decumbent stems. Leaves 2′–3′ long and up to ·5″ broad, strigose below and having a few tubercled hairs on the upper surface, densely hairy at the base. Infl. very dense

with an axis 5″–10″ long. Spikes subverticillate, repeatedly branched. Pedi. spkts. very small and often abortive. Pedicles and joints long white hairy.

Perennial; marked out by very dense infl. in the field; not very common. Flrs. December–January.

XI. BRACHIARIA

Rachis of the inflr. inarticulate; spkts. falling from their pedicles; unequally pedicelled and secund on the branch of main rachis; glume (i) always towards the axis.

A. Spkts. approximate—*distachya*, *milliniformis*, *eruciformis*, *ramosa*.

B. Spkts. distant—*kurzii*, *remota*.

33. *B. distachya* Stapf. Chanda, Mandla, Bastar.

A weak grass, height up to 18″ found in mostly forest blanks and under medium shade on sandy to sandy loam soils. It is generally marked out by a few horizontal spikes on a weak raceme.

Annual; a good fodder grass. Flrs. August–September.

34. *B. eruciformis*, Grieseb; *Surput*, *Chendi* (Hindi). Chanda, Bastar and Mandla.

A very weak grass with the spikes very close and erect. Spkts. ·05″–·06″ long and hairy. Very common in *Juar* fields.

Annual; ordinary fodder grass. Flrs. September–October.

35. *B. kurzii* Hains (*Panicum latifolium* F.B.I.).

Elev. (2000′). A common perennial grass along *nallah* banks forming dense tufts; leaves lanceolate with cordate base, stiff; spikes few and sparse on the rachis. Height up to 9″.

Perennial; not good fodder and dies back in summer due to fires. Flrs. October–January.

36. *B. miliniformis* Chase.

Kanhargaon nursery; a very weak decumbent grass up to 20″ high with spreading spikes; base of peduncle, hairy; spkts. over ·15″ long smooth. Leaf-sheaths and nodes hairy.

Annual; not very common; not good fodder. Flrs. September–October.

37. *B. ramosa* Stapf.; *Popti* (Hindi). Common.

A common grass with gibbous spkts. and ovate lanceolate cordate leaves, straggling. Infl. covered with long white silky hairs, which are not very dense.

Annual; a good fodder grass. Flrs. September–October.

38. *B. remota* (Haines) Stapf.; Kanhargaon, Chanda. Chanda, Mandla, Bastar.

A semi-xerophytic grass found on poor and lateritic soil specially on the sides of murrammy ditches; base of peduncle hairy, spkts. densely hairy. Leaves silky in touch, sheath-margins not hairy.

Annual; not very common and not good fodder. Flrs. September–October.

213. *B. reptans* (L) Gard and Hubb. Common.

A common sp. growing in association with *U. panicoides* Beauv, and easily identified by hairy spikes.

Perennial ; a good fodder grass. Flrs. September–October.

214. *B. setigera,* Stapf. Common.

A common grass in areas protected from grazing and fires. Spkts. about 2/3rd of the last sp. arranged on a long peduncled inflorescence. Weak straggling and rooting at nodes.

Annual ; a good fodder grass. Flrs. September–October.

XII. CAPILLIPEDIUM Stapf.

Infl. a compound panicle with elongated axis. Pedicles and joints with a medium translucent groove ; glume iv reduced and forms the base of the awn so that when the latter is pulled out there is no membrane attached to its base.

40. *C. huegelii,* (Hack) Camus. Bastar.

A weak grass up to 3′ in height with thyrsoid pinkish infl. common in clear-felled areas in Bija-dandi Coupes of Mandla Dn.

Annual ; not good fodder. Flrs. October–November.

41. *C. parviflorum,* Stapf.

Pedigundum range, Chanda, common in Mandla and Bastar.

A medium-sized grass common above 2000′ elevation growing in the forest ; infl. oblong with interlacing rachis, generally purple in colour.

Perennial ; generally growing under medium shade at lower elevations. Not good fodder. Flrs. September–November.

42. *C. subrepens,* Henr ; *Suna Ronda* (Halbi).

A common grass in sal forests ; stems decumbent, thick yellow shining ; branches of infl. stiff and at various angles.

Perennial ; grows under medium shade. Not good fodder. Flrs. September–December. *Ecological Var.* (Sheet No. 191). *C. subrepens* Henr. Kodeli, Bastar.

A tall grass up to 5′ high ; culms decumbent, polished, rooting at base, and grooved on the side of leaves and branches ; leaf up to 10″ × ·5″ ; nodes bearded. The sessile and pedicelled spkts. equal in size. Panicle oblong and very much branched and very strongly sweet-scented ; green to pale brown in colour.

Found in hilly tracts on lateritic soil under medium shade and blanks created by shifting cultivation.

Perennial. Flrs. November–December.

39. *C. subrepens* Henr. var. *glaucophyllum* Henr. Common.

A very tall, robust grass up to 6′ high ; nodes glabrous or hairy. Panicle copiously branched. It can easily be confused with *Pseudosorghum-fasciculare.* Back of glume (i) is hairy.

Perennial ; along *nallahs* over sandy loam soil ; not good fodder. Flrs. September–November.

XIII. CENCHRUS Linn.

43. *Cenchrus ciliaris* Linn. Chanda (Kanhargaon). Bhursa Ronda (Halbi).

Culms up to 20″ high ; infl. a simple spike ; spkts. surrounded by an involucre of bristles united at the base into a cup and falling with it, purplish in colour.

Annual ; rather rare ; said to be excellent fodder. Flrs. September–November.

XIV. CENTOTHECA Desv.

Spkts. many flrd. racemosely arranged. Empty lemmas 0–1 several usually with deflexed bulbous based bristles, awnless.

221. *C. lappaceae* Desv. Hari Marka *nalla*, Khorgaon Marsh ; ele. 2500′–3000′.

A medium-sized grass with lanceolate to ovate leaves up to 5″ × 1″ and generally pinkish stems. Infl. about 4″–6″ long. The sp. is easily marked out by deflexed hairs on the palea by which the spkts. get stuck on clothes.

Perennial ; under dense shade along *nallahs* or in marshes ; rare. Flrs. November–December.

XV. CHIONACHNER Br.

44. *Chionachner koenighi* Thw. ; *Bade Garha* (Madia), *Karpi, Karasali* (Hindi). Common.

A common tall coarse grass up to 6′ high with a single female flower (white-nut) at the base of the spike followed by many male flowers partly covered by a bract. The whole plant nearly covered with tubercle based white hairs.

Annual ; bad fodder ; very common in Allapalli plantations. Flrs. September–November.

XVI. CHLORIS SW.

Spikes digitate, umbellate and sometimes solitary ; spkts. 2-several flowered but only 1 or 2 fertile ; lemmas awned.

A. Spike solitary-*pallida*.

B. Spikes umbelled.

(i) Spike over 3″ long-*incompleta montana, barbata, virgata, delicatula.*

45. *C. barbata* SW. Dhamanpeth, Chanda.

A small grass up to 18″ high with beautiful pinkish coloured inflr. Rachilla bear 1–2 awned tubular or inflated glumes ; glume ii awnless.

Annual ; a good fodder ; collected from rice fields in Dhaba range. Flrs. September–November.

26. *A. delicatula* Ce ; Bastar (ele. 2000′).

A small annual grass 3″ to 9″ spkts. closely arranged on the alternate branches of the panicle.

Annual ; in the scrub jungle near Bhanpuri. Flrs. September–October.

46. *C. incompleta* Roth. Chanda, Mandla, Bastar.

A common forest grass growing under medium shade. In Allapalli, teak plantation has been very successful in areas with this grass.

Perennial ; good fodder. Flrs. October–January.

47. *C. montana* Roxb. Chanda, Mandla, Bastar.

A common grass on poor and rocky areas. Rachilla with 3 to 4 barren awned glumes.

Annual ; not good fodder. Xerophytic. Flrs. September–November.

48. *Chloris pallida* Hook. Mandla, Bastar, Chanda.

A small grass up to 12″ in height ; infl. one single spike with long awned biseviate spkts.

Annual ; growing on sandy, lateritic and gravelly soil ; xerophytic. Flrs. September–November.

49. *Chloris virgata* SW. Chanda, Mandla, Bastar.

One of the commonest sp., growing along road-sides and in grazing ground with soft, close, pale, spike ; Rachilla with 1 to 2 tubular glumes.

Annual. Flrs. September–November.

XVII. CHRYSOPOGON Trin.

Panicle with long flexuous branches ; spkts. 1 sessile and 2 pedicelled and laterally compressed. Joints and pedicles without translucent groove.

50. *Chrysopogon aciculatus* Trin. ; *Karkasa* (Halbi). Mandla, Bastar.

A small grass up to 15″ high ; stems creeping ; leaves tufted at base ; infl. erect, stiff pyramidal, purplish.

Perennial ; found in heavily grazed grassland and seldom seen in forest. A good fodder before flowering. Flrs. August–September.

217. *Chrysopogon asper* Heyne ex. Hook. f. ; *Hotel-tokar* (Madia). Matla block Bastar. (Photo No. 4 and 3).

A tall tufted stiff and coarse grass up to 6′ high ; leaves distichous, up to ·4″ × 15″, semi-amplexi-caul. Glume of sessile spkts. ·2″–·22″ and of the pedicelled ·33″–·5″ long. The pedicel tips clavate rufous hairy and easily mark out the sp.

Perennial ; on plateaus and hills above 2000′ elevation.

51. *C. lancearius* Haines. Mandla, Chanda, Bastar.

A tall stout grass up to 5′ in height marked out by large golden yellow pyramidal infl.

Perennial ; along hill slopes generally in association with *Sorghum nitidum*. A good plant for flower-pots and may be planted in gardens. Not good fodder. Flrs. August–October.

52. *C. montanus* Trin. ; *Koda-Ronda* (Madia). Chanda, Mandla, Bastar.

A very common grass, on over-grazed, hilly and lateritic soils growing in open, up to 3′ high ; stems creeping. Panicle thyrsoid, golden yellow to purplish 2″–3″ long.

Perennial ; gregarious. A good fodder grass. Flrs. September–November.

53. *C. polyphyllus*, Blatt and McCann. Mandla, among the rocks in the Nerbuda River. Khandya Dongri, Bastar.

A rare grass growing among rocks strewn in the river liable to submersion during the rains, marked out by the spkts. being covered with long plumose golden shining hairs from the pedicles.

Perennial ; a good fodder. Also a good plant for flower pots. Flrs. October–November.

XVIII. COELORHACHIS

55. *Coelorhachis clarkei* Blatter and McCann. Mandla, Bastar.

A small grass up to 18″ in height, weak very much branched, spikes straw coloured ; leaves covered with white hairs.

Annual ; very common along hill slopes and in *kodokutki* fields. Flrs. August–September.

XIX. COIX Linn.

56. *Coix lachryma-jobi* Linn.; *Kasa* (Halbi), *Kasai*, *Garu* (Hindi). Mandla, Chanda, Bastar.

A tall coarse grass growing along water-courses and ditches. Spike with a single female flower at base and a series of 2-nate male flowers above. Easily marked out by the white nut overtopped by a bunch of male flowers.

Annual; useless as fodder. Flrs. October–December.

57. *C. gigantea* Kon ; Chanda (Mulchera).

Tall grass up to 15′ high, leaves covered with short hairs with big bulbous bases. Male spkts. 3-nate about ·5″ long ; their glume (i) winged inflr. sometimes without female flr.

Perennial. Flrs. September–October. Useless as fodder.

XX. CYMBOPOGON Spreng.

Aromatic grasses. Panicle spatheate ; spkts. in pairs of 1 sessile and the other pedicelled on geminate spikes. Lowest joint often much thickened.

C. caesius Stapf.

A tall lax grass up to 5′ high growing mixed with *C. martinii*, Wats.; leaves and inflorescence slightly scented.

Perennial ; commercially not very useful. Flrs. October–December.

59a. *C. flexuosus* Wats. Mendhaghat, Matla block.

Caespitose grass up to 5′ tall. Peduncles very slender and as long as or slightly shorter than the spatheoles. Spikes not tightly arranged. Glume of sessile spikelet ·15″–·17″ long dark purplish with a nerve on the margins, its back flat and sometimes faveolate. Basal leaves ·25″ broad and up to 2′ long. Leaves on the stem much smaller and broader.

Perennial ; on high hills ele. 3000′. Rare. There is hardly any smell in the inflorescence.

58. *C. martinii* Wats. ; Rusa grass. Mandla, Bastar.

A sweet-scented grass, tall up to 4′ ; very common above 1800′ on hill slopes and plateaus. Back of glume of sessile spkts. grooved below middle.

Perennial ; very common in Betul, Chhindwara, Mandla and Bastar ; yields the commercial Rusa grass oil. Flrs. October–December.

59b. *C. nardus* Rendle. Bastar (Photo No. 5).

Caespitose grass with tufted basal leaves. It appears that the main stem is found only at the time of flowering. Basal leaves long, narrow up to 18″ × ·3″, upper leaves much smaller. Panicle interrupted, spikes very tightly arranged inside the spathiole (4 to 5). Peduncle hardly 1/3rd of the spathiole with the result that the spathioles are quite conspicuous. Marginal nerve of gl. (i) of sessile spkts. not very prominent.

Perennial ; on high hills (above 2500′), fairly common ; the spikelets give out a very strong camphorous smell when pressed and when dissected.

(to be continued).

TERMINALIA PANICULATA, ROTH. W. & A.

Syn. *Pentaptera paniculata*, Roxb.
(Family : Combretaceae)

BY K. KADAMBI
Central Silviculturist, Forest Research Institute, Dehra Dun

Vernacular names—Marathi : *Kindal, kinjol, kirijul ;* Tamil : *Puluvai, poomaradu, pulavadi, pillamaradu, venmarudu ;* Anamalais : *Pekarakai, Pillaimaradu ;* Travancore : *Pullamarathu, villimarathu ;* Telugu : *Neemeeri, pulamaddi ;* Coorg : *Hongal, hulluwai, ulwe ;* Kannada : *Huluve, hunagalu, hunal, hunab ;* Mangalore : *Marwa, uluve, ulvi ;* Central Kanara : *Bili-mathi ;* Malayalam : *Pumardu, pumaruthu, vermaruthu, pilamaruthu.*

General – *Terminalia paniculata* is a large to very large, deciduous tree, the lower part of the bole of which is often fluted. The bark is about half inch thick, dark brown, rough, with numerous, shallow longitudinal and transverse fissures. The trees show up conspicuously in autumn when their crowns exhibit themselves as purple red patches all over the forest on account of the ripe, winged fruits which cover them at this time. Tireman has recorded a tree 13¼ ft. in girth in Coorg forests, while Pearson quotes a tree of 20 ft. girth in the forests of Cochin ; such large trees are mostly hollow.

Botanical description – *Leaves* glabrous, oblong, often from an unequal base, pale brown below ; leaf blade 4 to 7 in., the upper leaves alternate, the lower often opposite. *Flowers* in ample rusty pubescent panicles, bracts pubescent, acuminate. *Ovary* with five rounded ridges. *Fruit* ¼ to ½ in. long, rusty pubescent, sessile, close-set in large spreading panicles ; ridge of the ovary expanding into a purple coloured wing about an inch broad.

Locality and habitat—The tree is found in the tropical semi-evergreen and the tropical moist-deciduous forests of the Western Ghats from Kolaba southward through North and South Kanara, Malabar, Coorg to Travancore (Fig. 2). It also occurs, though attaining a smaller size, on the open Deccan tableland, lying to the east of the above zone, as well as in the Eastern Ghats areas of the Karnatic hills of Vellore, Satara, Cuddappah, Salem, Bellary and Madurai. Its altitudinal range is from almost sea level (100 ft.) up to 3,500 ft. in the Western Ghats and to 4,000 ft. elsewhere. The best dimensions are attained by the tree in a narrow strip of forest all along in the Western Ghats where the forest type is in a transition stage from the typically moist-deciduous to the semi-evergreen. Trees of 12 ft. girth and 120 ft. height are found here.

In Bombay State the tree is found in the Roha, Mangaom, Mahad and Nagothna areas of Kolaba district, and in the Kanara divisions, where it occurs in the transition forests from moist-deciduous to semi-evergreen, covering an area of about 400 square miles. In this State, the tree attains its best sizes in the Western Ghat forests of Kanara, where occasionally breast height girths of 12 ft. and top heights of 80–90 ft. and clear boles of 35–40 ft. are found. On the plateaux, in Satara, Dharwar and Belgaum divisions, the trees are small, being 3 to 5 ft. in girth and 60 ft. high, decreasing in size as one goes further east. In Kolaba district which is the northern limit of its distribution it attains a girth of only 4 ft. and a height of 60 ft.

In Madras State, the tree is common in the forests of Mangalore district, but it is more abundant in South Malabar forests, where in places, it is probably the most abundant single species found. Here, too, exceptionally large trees of 12 ft. girth and 120 ft. high are found. Logs 50 ft. long and 7 ft. 7 in. mid-girth and 37 ft. long and 8 ft. 10 in. mid-girth are stated to

FIG. 1.
Terminalia paniculata.

Photo : Author.

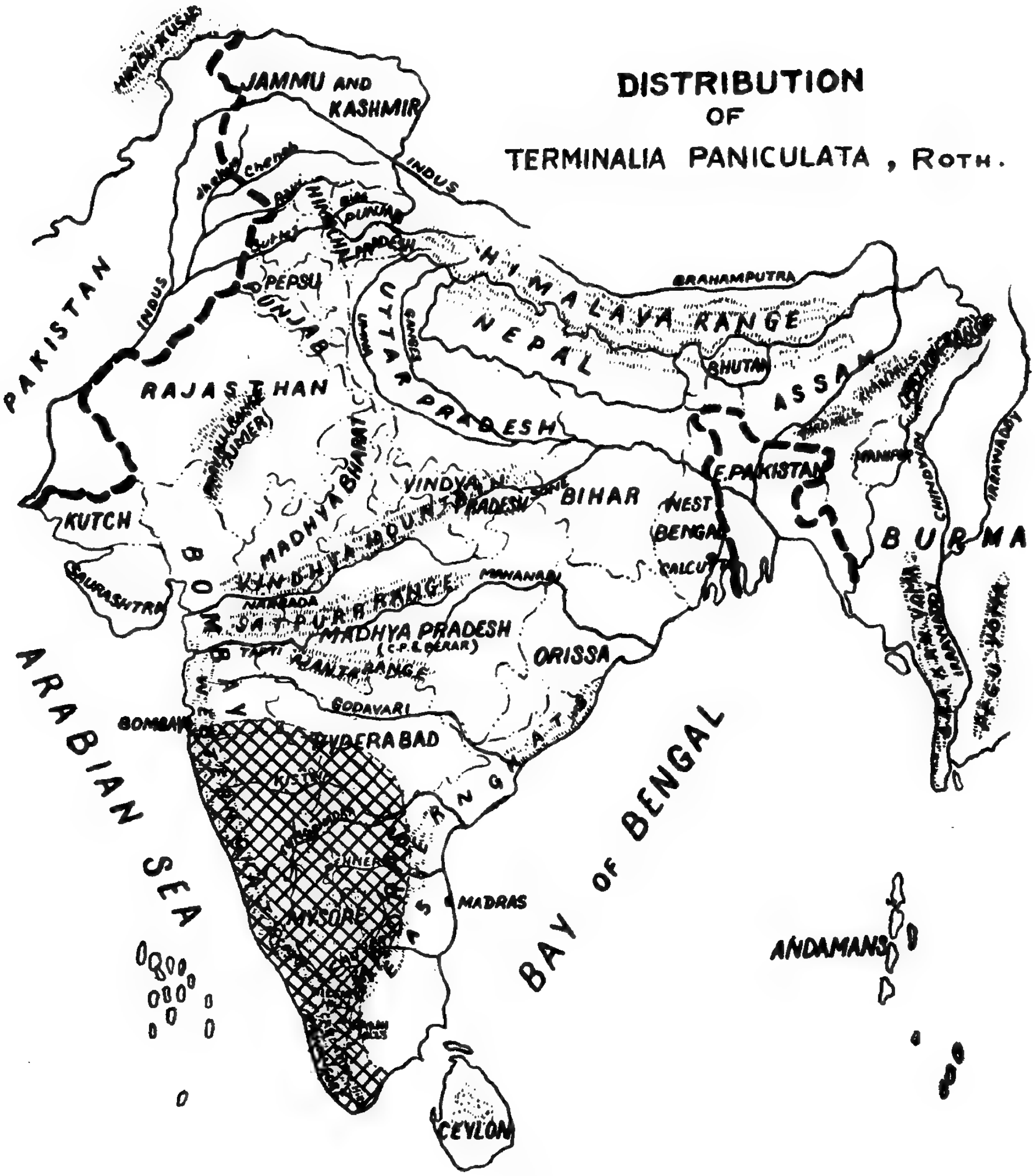
DISTRIBUTION
OF
TERMINALIA PANICULATA , ROTH.
JAMMU AND
KASHMIR
INDUS
PAKISTAN
PEPSU
PUNJAB
HIMALAYA RANGE
NEPAL
BRAHAMPUTRA
BHUTAN
ASSAM
UTTAR PRADESH
RAJASTHAN
VINDYA
BIHAR
WEST
BENGAL
E.PAKISTAN
MANIPUR
BURMA
KUTCH
SAURASHTRA
MADHYA BHARAT
VINDHYA RANGE
NARBADA
SATPURA RANGE
MADHYA PRADESH
(C.P. & BERAR)
ORISSA
TAPTI
GODAVARI
BOMBAY
HYDERABAD
ARABIAN SEA
BAY OF BENGAL
MYSORE
MADRAS
ANDAMANS
CEYLON

FIG. 2.

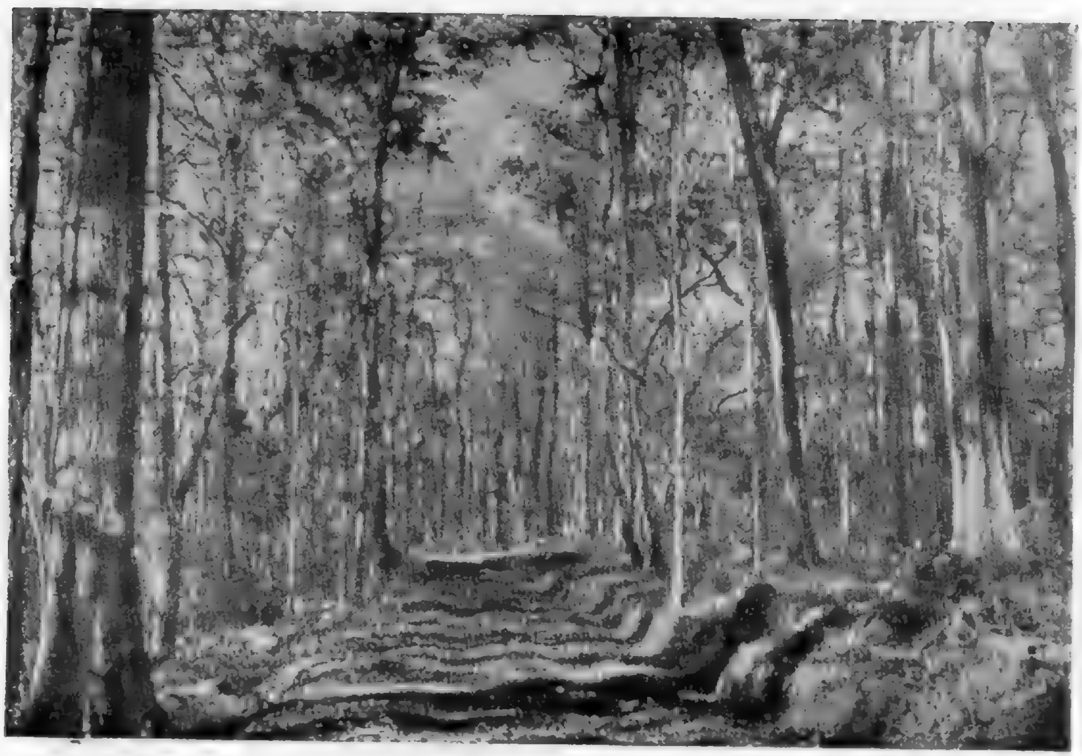

FIG. 3.
Mixed crop of *Terminalia paniculata* and *Xylia xylocarpa*, Nilambur (Madras).
Photo : P. W. Davis.

FIG. 4.

Moist deciduous forest, probably secondary to evergreen which closely adjoins from left: dead *Bambusa arundinacea*, *Terminalia paniculata*, *Dillenia pentagyna* (leaning), *Lagerstroemia lanceolata* (white), *Grewia tiliaefolia*, *Phyllanthus emblica*, *Lagerstroemia lanceolata*, *Stereospermum chelonoides* (near, crooked), *Adina cordifolia* (behind last). Karian Shola, South Coimbatore Division, Madras.

Photo: H. G. Champion.

have been measured here. In the easterly divisions of Vellore and North Salem, however, the tree does not attain a girth of more than 4 to 5 ft. In West Vellore it covers Thenmalai and Javadi hills while in South Vellore it occurs scattered on the Tewadi and Kalrayan hills. In Central Coimbatore it is found scattered in the dry-deciduous forests up to 2,000 ft. while in South Coimbatore in the moist-deciduous forests of Anamalais, it ascends to 3,000 ft. It is rarely seen in North Salem.

In Mysore State, the tree is mostly found in the moist-deciduous (locally called mixed-deciduous) belt of forests covering the foot-hills of the Western Ghats in the districts Shimoga and Kadur, where it attains also its best sizes, trees of $7\frac{1}{2}$ ft. and over in girth being fairly common, though the majority of such trees are hollow. It also extends into the open, dry, plateaux forests of Bangalore, Tumkur and Kolar districts where, however, it attains but small sizes.

In Coorg, the tree is found scattered over an area of about 60,000 acres in the moist-deciduous forests towards East and North between elevations of 2,000 to 3,500 ft.

In Travancore-Cochin the tree goes up from near sea-level to 2,000 ft. It is found in considerable quantities and also attains very large dimensions at the fringe of the evergreen forests, trees of 10 to 12 ft. girth being common.

Climate and Rainfall—In the natural habitat of the tree the absolute maximum shade temperature varies from 95° to 102°F. the minimum from 55° to 65°F. and the rainfall from about 30 to 200 inches.

Geology, rock and soil—In a broad and general way it can be said that the tree is a native of the areas where the parent rock is of the crystalline series, overlain or not with laterite. In the Western Ghat zone the best growth of *Terminalia paniculata* is found on the laterite covered soils both at the foot of the ghats and above it at the edge of the Deccan plateaux. Underneath this laterite cover, the rock generally consists of metamorphic schists and crystalline gneiss with granite and quartzose intrusions. On the lower ghats and foot-hills, the original rock, which is sometimes laminated, weathers into a pale, cankered, easily friable material, which finally reduces to a yellowish or pale coloured felspathic clay or loam often reaching considerable depth. Lower down on the plains the soil has a heavy clayey structure. Gneissic boulders often come to the surface, especially at the edge of the forest.

In the Anamalais area of Madras the underlying rock is gneiss and the tree thrives on the rich, sandy loam resulting from the decomposition of the parent rock. Here, too, some areas contain disintegrated laterite on which the tree generally flourishes along with *Xylia xylocarpa*.

Elsewhere in the dry plateaux forests of the Deccan, the tree exists in localities where the rock consists mostly of granitic gneiss in various stages of disintegration, giving rise to red, clayey loam both on the plateaux and in the valleys where *Terminalia paniculata* is found scattered.

Forest types and tree associations – Terminalia paniculata occurs in following forest types :—

(I) West coast tropical semi-evergreen (Champion's C. 2), (II) Indian tropical moist-deciduous (Champion's C. 1) and (III) Southern tropical secondary moist-deciduous [Champion's 2S/6(a)]. Type (I), mentioned above, extends all along the Western Ghats as a narrow strip wedged in-between the wet-evergreen and the moist-deciduous. The rainfall here ranges from about 80 to 150 inches, and the altitude from 1,000 to 3,500 ft. The forests type is rather variable and difficult to describe properly except in comparative terms. It is generally confined to localites where the moisture conditions are better than what is needed

to develop a moist-deciduous forest type, but is inadequate for an evergreen climax. This latter type is also frequently encountered as a localized edaphic sub-climax to the tropical evergreen, this being well illustrated in the *Lagerstroemia* – association encountered at the fringe of the tropical moist-evergreen forest. In this semi-evergreen zone were *T. paniculata* has its home and attains its maximum sizes, the soil is a red loam, deep, being the weathered product of the laterite which in places is 30 ft. deep. The underlying rocks are crystalline. Here *Xylia xylocarpa* and *Terminalia paniculata* are the most typical tree species (Fig. 3) and *Bambusa arundinacea*, the characteristic bamboo. The ground cover is made up of evergreen shrubs of the Acanthaceae and the Rubiaecae.

The following are a few typical localities in which this type occurs ; *Bombay State* : (1) *Satara district semi-evergreen forest.* Floristics—*Eugeina jambolana*, Mango, *Careya aborea*, *Lagerstroemia lanceolata*, *Holoptelia intergrifolia* and *Terminalia paniculata*. (2) *North Kanara*—(Bombay State) *Semi-evergreen ghat forest ; Rainfall*—80 to 150 in. ; Soil – lateritic loam, *Principal species : Terminalia paniculata*, *Lagerstroemia lanceolata* (both characteristic species), *T. belerica*, *Machilus macrantha*, *Polyalthia coffeoides* and others (Bombay tour notes of the author).

Mysore State : Local edaphic sub-climax formation of the *Agumbe sub-evergreen forest zone.* Soil – loam with laterite nodules out-cropping ; rainfall 200 inches. *Tree species – Lagerstroemia lanceolata* (characteristic tree) *Careya arborea*, *Buchanania latifolia*, *Plectronia didyma*, *Mallotus philippinensis* and stunted trees of *Terminalia paniculata*, *T. tomentosa*, *T. chebula*, *T. belerica*, *Dalbergia latifolia*, *Butea frondosa*, *Bombax malabaricum* and *Alstonia scholaris.* (Working Plan for the Ghat forests Agumbe, etc., Shimoga and Sagar divisions 1945, pp. 22–23).

Gilalgudi kan Forest :—Tree species : Holigarna sp., *Amoora* sp., *Artocarpus hirsuta*, *Vateria indica*, *Bischofia javanica*, *Litsea* sp., *Mimusops* spp., *Terminalia paniculata* (a survival from the deciduous forest) and many others. (W.P. for the forests adjoining the Sagar—Anandapuran Ry., 1943, p. 15).

Coorg : Semi-evergreen forest : *Tree species : Artocarpus hirsuta*, *Eugenia jambolana*, *Lagerstroemia lanceolata*, *Linociera malabarica*, *Casaeria tomentosa*, *Dalbergia latifolia*, *Melia dubia*, *Terminalia* spp., *Careya arborea*, *Cedrela toona* and others.

South Kanara—Ghat foot-hills : *Tree species* : *Artocarpus hirsuta*, *Hopea parviflora*, *Dalbergia latifolia*, *Terminalia paniculata* and *T. tomentosa*, Mango, etc. (Working Plan for the South Mangalore Forest Division, Madras by P. W. Davis).

Madras State : (1) Malabar : Ghat slopes above Nilambur : *Tree species* : *Terminalia paniculata*, *Xylia xylocarpa* (both characteristic trees, Fig. 3), *Stereospermum chelonoides*, *Vateria indica*, *Canarium strictum* and others (Champion, p. 56) ; (2) South Kanara : *Tree species* : *Terminalia paniculata* (characteristic species) *Diospyros* spp., *Lagerstroemia lanceolata*, *Holigarna arnottiana*, *Lophopetalum wightianum* and *Hopea parviflora* (characteristic species. (Champion, p. 57).

Travancore-Cochin : Semi-evergreeen forest—found at elevations of 800 to 2,000 ft. *Tree species* : *Lagerstroemia lanceolata*, *Terminalia paniculata*, *T.* spp., *Bischofia javanica*, *Cedrela toona*, *Holigarna* spp., Mango, *Hopea parviflora* and others. Weed growth is profuse. (Working Plan of Shencottah division forest, by M. N. Menon, p. 12).

(II) *South Indian tropical moist-deciduous forest*—This type is met with throughout the peninsula wherever rainfall is adequate, but is mainly found as a strip fringing the semi-evergreen forest described above, on the eastern side of the crest of the Western Ghats. Rainfall – from 50 to 80 in. or locally more. Soil – lateritic loam, red loam in situ or dark coloured

sandy loam. *Characteristic trees*—Teak of excellent development is found wherever the soil permits, also *Terminalia* spp., *Pterocarpus marsupium*, *Lagerstroemia lanceolata* and *Xylia xylocarpa*. *Bambusa arundinacea* is the typical bamboo and *Dendrocalamus strictus* occurs in the drier outlying portions.

The following are a few typical localities.

(1) *Kanara Northern Division*, Nagazari valley and Kalinadi – Kaneri slopes :—*Tree species*—*Terminalia paniculata*, *Lagerstroemia lanceolata*, *Dalbergia latifolia* and *Xylia xylocarpa* which is often very abundant and the bamboo *Bambusa arundinacea* (Author's Bombay tour notes), or teak, *Terminalia paniculata*, *Grewia tilaefolia*, etc., and *Dendrocalamus strictus*. (Working plan for Nagazari valley, Kalinadi–Kaneri slopes, Kanara Northern Divisions, by S. N. Kesarkodi, p. 3).

(2) *Karadibetta – Gilalgundi zone, Sagar Division*, Mysore State. (a) *Teak – sub-type*—This is the drier type and has considerable variety of species, the chief ones being teak, *Anogeissus latifolia*, *Dalbergia latifolia*, *Terminalia tomentosa*, *T. paniculata*, *Pterocarpus marsupium* and others. *Undergrowth – Flemingia* and *Clerodendron* spp., *Dendrocalamus strictus*. (b) *Xylia – sub-type* – Here *Xylia xylocarpa* preponderates, its associates being *Terminalia paniculata*, *T. tomentosa*, *Lagerstroemia lanceolata* and others ; *Bambusa arundinacea* is the principal bamboo. (Working plan for the forests adjoining the Sagar – Anandapuran Railway, Sagar Division, Shimoga district, 1943).

(3) *Muthodi, Bhadravati division*, Mysore—*Terminalia tomentosa*, *Grewia tilaefolia*, *Dalbergia latifolia*, *Terminalia peniculata*, *T. belerica*, teak, *Lagerstroemia lanceolata*, *Xylia xylocarpa*, *Bambusa arundinacea* and *Dendrocalamus strictus*. (Working plan for the forests of Bhadravati division, Mysore State, 1941).

(4) *South Coimbatore Division, Mt. Stuart Forests*, Madras—On good, deep soil occur : teak, *Dalbergia sissoides*, *Terminalia tomentosa*, *T. paniculata*, *Lagerstroemia lanceolata*, *Pterocarpus marsupium* and several others with *Bambusa arundinacea* (Fig. 4). (Working plan for South Coimbatore Dn., by T. V. Venkateswara Iyer, p. 8 and for Mt. Stuart forests by M. V. Laurie, p. 9).

(5) *Travancore-Cochin ; Shencotta division*—In moist-deciduous and dry deciduous forests—Teak, *Pterocarpus marsupium*, *Terminalia paniculata* and other *Terminalias*, *Lagerstroemia lanceolata*, *Xylia xylocarpa*, *Dalbergia latifolia*, *Adina cordifolia*, *Albizzia* spp., *Grewia tilaefolia* and several others. (W.P. for Shencotta Dn., by N. N. Menon, p. 13).

(III) *South Indian Tropical Secondary moist-deciduous*—Very similar to the climax, but probably of secondary origin the climatic climax having been displaced by human action—*example – Parappa, S. Mangalore division* of Madras ; trees : *Terminalia paniculata* (characteristic), *Bombax malabaricum*, Mango, *Lagerstroemia lanceolata*, *Xylia xylocarpa*, *Schleichera trijuga* and others. No bamboo. Evergreen undergrowth.

Leaf Shedding, flowering and fruiting—The tree is hardly ever quite leafless. The height of the shedding season is in the hot weather, February (Wynaad ghats), March (Mysore plateaux), when there is minimum foliage on the trees. The small white flowers appear in bushy pubescent panicled spikes. Flowering season varies. The flowers appear in repeated flushes succeeding one another and this probably accounts for the variations in the flowering season noticed by different authors. There seems to be one pre-monsoon and one late monsoon flowering season, the latter of which may extend up to December. Brandis gives the flowering season as August to December and Talbot (Bombay) as August to September. Bourdillon (Travancore) as July to December ; Sharma (Wynaad ghats) and Tiremen

(Coorg) as April–May. On the Mysore plateaux there are two seasons, one pre-monsoon April–May and one late monsoon – August to October. The fruits ripen from December to May. Brandis has mentioned that the fruits ripen in the hot season, and Sharma (Working plan for the Wynaad Ghat Forests, Wynaad Divisin, Madras, 1934, p. 10) says that they ripen in March. Each fruit has one large wing up to 1 in. long. About 110 fruits weigh one oz.

Silvicultural characters—The tree tolerates moderate shade, being less light-demanding than *Terminalia tomentosa*. Heavy shade is harmful to it and on the whole this tree can be classed as light-demanding rather than shade bearing. This accounts for the fact that the optimum conditions for its growth are found in the forest which represents a transition from the typical moist-deciduous to the typical semi-evergreen. Though thriving best in valleys, stream banks and moist situations, this tree unlike *T. tomentosa*, thrives only on well-drained soils and avoids heavy, stiff, clayey ones. It is fairly drought resistant and coppices well up to a moderate size. In the firewood forests of Bhadravati division, Mysore State, very vigorous coppice shoots emerge ofter the fuel fellings. (For. Adm. Rpt. Mysore, 1937, pp. 14–15).

Reproduction – Natural and artificial—The tree reproduces itself freely in nature. The seedlings establish themselves soon but the parts above ground are either burnt back or die back every year for four or five years or more until the root-stock puts out a strong leader which survives the dry season. The Divisional Forest Officer, Chalakudi says that in Travancore its reproduction is very common along stream-banks (Report No. cc3-670/51, dated 26–6–51 from the D.F.O. Chalakudi).

Its light demanding nature asserts itself in the sapling stages and often prevents its seedling from emerging through the dense forest undegrowth. But it can withstand a good deal of lateral shade, which accounts for the fact that the edges of blanks are often seen covered with its seedlings. It is also likely that on roadsides, where its seedlings and saplings are often plentiful, it is able to thrive because weed growth is being kept down. Troup mentions that its natural reproduction is as a rule plentiful, but this applies obviously to the better quality moist-deciduous forests where the tree has the optimum conditions required for its growth. In the fire protected, moist-deciduous zones of N. Kanara and S. Kanara, which are progressing towards a semi-evergreen type, however, the natural reproduction of the tree is suffering a set-back, more or less like that of teak under similar conditions. In the dry localities of the more eastern districts such as the Tumkur district of Mysore, and Vellore and North Salem of Madras its natural reproduction is not so good as in the more moist localities, the limiting factor here being drought. Newly exposed ground, with well worked soil, such as what we fine in *kumris* is probably very advantageous to the natural reproduction of this tree. At Nilambur, on laterite soil, a high death rate among natural seedlings has been noticed during the hot season in the open forest clearings where there is no shade of any kind.

Attempts made at the artificial reproduction of *Terminalia paniculata* have shown that the tree is not quite easy to raise by artificial means. But, this is not of much importance because, in favourable localities where the tree has its optimum growth conditions as on the West Coast, natural reproduction of the tree is often profuse. The tree has been successfully raised by broadcast sowing in North Mangalore (Bombay) where the plants attained a height of 8 ft. in 6 years. In South Coimbatore, broadcast sowing was tried but failed probably owing to drought, while the dibbling of seed tried in South Malabar also did not succeed.

Seeds of *Terminalia paniculata* are usually collected in March–April (Madras). Seed size varies considerably and 740 to 1,700 seeds weigh one oz. The seeds can be stored in gunny bags or air-tight containers for 5 months, but they are not always certain to keep good. The seeds are proverbially infertile. Germinative capacity is very low—having been given as 2 per

cent by Sen Gupta (Ind. For. Rec. n.s. Vol. II, No. 5, 1937) and as 2 to 16 per cent in Madras (Silv. Res. Report, Madras, 1938, Pt. II, pp. 131–33). Viability does not vary within the fruiting season, (Madras, Silv. Res. Report, 1938–39, p. 11), though seed collected very early in the season, like January–February, does not germinate at all. Pre-sowing treatment of seed with hot or boiling water does not improve its germinative capacity (Silv. Res. Rpt., Madras, 1939–40, pp. 9–11), nor does manuring the soil or burning the nursery beds in which seed is sown improve matters. R. S. Browne has mentioned (W.P. of the Nilambur valley 1928 to 38) that a large proportion of the seeds of this tree is usually infertile, and that the percentage of infertility varies from year to year. The infertility has been ascribed by some, partly if not wholly to a weevil which attacks the seed.

Stump planting is the best known method of raising *Terminalia paniculata* artificially, transplanting being the next best. Direct sowing is not satisfactory because of the high percentage of infertility of its seed. The following statement shows the results of experimental work done in this connection at various centres in Madras.—(Ann. Silv. Res. Rpt., 1942–43, p. 16).

Terminalia paniculata

Comparison of the results of direct sowing, entire transplanting and stump-planting in nursery :—

Locality (Name)	Year of starting the experiment	Results after 3 growing seasons of :					
		Sowing	Trans-plants	Stumps	Sowing	Trans-plants	Stumps
		Survival per cent			Mean height growth (inches)		
Anappadi ..	1940	7	35	61	71·0	119·0	134·0
Begur ..	,,	16	83	81	107·0	126·0	146·3
Dhoni ..	,,	24	71	83	43·5	50·1	57·8
Kannoth ..	,,	3	46	56	85·3	89·9	97·8
	Average ..	13	59	70	70·3	95·0	108·7

Artificial reproduction by planting branch cuttings of the tree has been tried but found unsuccessful. It would therefore appear that the best method of raising this species in a west cost type of climate is to sow the seed very thickly in nurseries, possibly under shade of some kind, tend the resulting seedlings during the first year and plant them out as stumps at the end of the year. On soils of the west coast type where laterite abounds, it may be found advantageous to plant the species under light shade than out in the open. Experiments conducted in Nilambur to find out the relative advantage of planting out entire plants of this species in the open, and under light and moderate shade on laterite soil showed that after the first hot weather only 9 per cent of the plants survived in the open, as against 48 per cent under moderate shade and 60 per cent under light shade (Working plan for Nilambur Valley, R. S. Browne, 1928–38).

External dangers and protection—The infertility of the seed of *Terminalia paniculata* is caused, among other things, by the attack of the weevil *Nanophyes terminaliae*, Mshll. and other insects which attack both the flowers and young fruits, among which *Garella rotundipennis* (Noctuidae) seems to be the most important. [Letter No. 227/113–57 (a) dated the 5th

April 1946, from the Forest Entomologist, F.R.I. Dehra Dun, to the P.S., Ootacamund]. It is considered highly probable that the insect concerned lays its eggs very soon after the fruit begins to form. Experiments in spraying a solution of arsenate of lead, one pound in fifty gallons of water, have been carried out but the results are not conclusive. Improved spraying technique using oil or adhesive spray may prove more useful. (Letter No. A 2365/44 dated 27th November 1944 from the Silv., Madras, Ootacamund, to the Central Silviculturist).

Statistical—Under favourable conditions, the rate of growth of this species is moderately fast. At Begur (Madras) experimental garden one year old stumps attained heights of 19·5 in., 76·7 in. and 146·3 in. after 1, 2 and 3 growing seasons respectively.

The following table gives the details of heights attained by the species in the experimental gardens at various centres of Madras State :—

Terminalia paniculata :—Height growth of seedlings raised by transplanting and stump planting in experimental gardens :—

Place	Height of seedlings attained after					
	One growing season		Two growing seasons		Three growing seasons	
	Transplants (inches)	Stumps	Transplants (inches)	Stumps	Transplants (inches)	Stumps
Anaipadi ..	8·7	13·1	60·4	83·0	119·0	134·0
Begur ..	18·0	19·5	70·4	76·7	126·0	146·3
Dhoni ..	5·0	10·0	18·5	29·8	50·1	57·8
Kannoth ..	—	—	50·8	63·1	89·4	97·8

(Silv. Res. Rpt., Mad., 1942–43, p. 16)

Under natural forest conditions, however, where the species dies back for a number of years, such rapid growth cannot be normally expected. Information about its rate of growth in natural forest is difficult to obtain because the tree does not exhibit distinct annual rings. Attempts made in this connection in the West Kanara forests have indicated that in forests of the Kalinaddi slopes the trees reached a diameter of 24 in. in 120 years and in the Ankola forests they took 145 years to attain the same size. (Note on Kindal or Hongal, by R. S. Pearson, Ft. Bull. No. 48, 1922, p. 5). The Castle Rock Working Plan of N. Kanara Division, Bombay State, has estimated that the tree takes 40 to 45 years to reach 8 in. breast height diameter.

The table on the next page 619, shows the rate of growth in diameter, based on the results of ring – countings recorded in the working plans of the N. Kanara district, Bombay.

As regards rate of growth of coppice, measurements of 58 stems by Ranger T. V. Armugam Pillai recorded for the Thampurathipottai reserve of the ghat forests of Palghat Division have indicated a mean annual girth increment of 2·4 in. for a 7-year old coppice crop. (W.P. for the Ghat Forests of Palghat Division, 1933–34 to 1942–43, by T. V. Venkateswara Iyer 1935, pp. 83–84).

Terminalia paniculata: *Growth in diameter in high forests of the North Kanara district, Bombay*

Age years	Supa fuel reserves 1 (1906)	Ankola high forest, Blocks xxiv and xxv, 2 (1908)	Kalinaddi slopes, Block xxvi, 3 (1909)	Sopinhosalli high forest, Block xxvii, 3 (1910)	Ankola–Kumta coast, 3 (1911)	Sirsi town forest, 3 (1913)	Yekambi–Sonda high forest, Block xxvii, 3 (1914)
	in.	in.	in.	in.	in.	in.	in.
10	2·1	2·1	2·2	1·2	1·8	1·0	1·2
20	4·2	4·1	4·4	2·8	4·0	2·4	2·8
30	6·6	5·9	6·6	4·4	6·3	3·8	4·8
40	9·2	7·7	8·8	6·4	8·5	5·4	7·0
50	11·8	9·5	11·0	8·5	10·8	7·2	9·4
60	13·3	11·2	13·2	10·5	13·0	9·0	11·5
70	..	12·9	15·2	12·6	15·2	11·1	13·5
80	..	14·6	17·1	14·6	17·4	13·3	15·4
90	..	16·2	19·0	16·7	..	15·1	17·0
100	..	17·8	20·7	18·8	..	16·6	18·5
110	..	19·4	22·5	20·9	..	17·7	20·0
120	..	20·6	24·1	23·0	..	..	21·5
130	..	22·0	25·4	..	..	..	23·1
140	..	23·3	26·4	..	..	..	24·7
150	..	24·2	27·2	..	..	..	26·4
160	..	24·9	27·6	..	..	..	..
170	..	25·6	..	..	..	..	..

Note.—Diameter excludes bark. Average bark thickness 0·4 in. in Ankola high forest and Kalinaddi slopes, 0·6 in. in Sopinhosalli high forest.

Troup has recorded the following measurements made by H. A. Gass in 1898–99 in the Kadike block of South Kanara district, Madras.

Terminalia paniculata : *Coppice measurements*

Age years	Girth in.	Height ft.	No. of shoots per stool
2	8	15	2
	4	18	4
	7	15	6
3	10½	15	8
	9½	12	
	9½	18	
	14	20	
	12	18	

Volume Tables—The following table, which is based on 900 trees felled in the Conversion Working Circle, new Amarampalam Range, Nilambur, Madras was compiled by the logging branch of the Madras Forest Department :—

Terminalia paniculata : *Volume outturn tables**

Girth at breast height	Merchantable length for bole in feet — Volumes in c. ft.									
	10	15	20	25	30	35	40	45	50	55
4′ to 4′ 11″	16	22	27	32	36	40	46	..	..	..
5′ to 5′ 11″	24	30	35	40	45	49	55	..	..	..
6′ to 6′ 11″	32	39	44	48	52	58	66	73	77	79
7′ to 7′ 11″	37	45	51	56	60	66	76	83	87	90
8′ to 8′ 11″	42	51	59	67	73	78	90	95	99	102
9′ to 9′ 11″	..	59	71	83	91	97	104	110	115	118
10′ to 10′ 11″	..	71	86	99	106	110	116	123	128	132
11′ to 11′ 11″	..	84	100	111	116	120	126	131	135	139
12′ to 12′ 11″	..	..	112	121	126	130	135	139	143	147
13′ to 13′ 11″	..	..	121	129	135	140	144	148	152	154
14′ to 14′ 11″	..	..	127	136	143	148	152	157	161	165

Note.—Only volumes in classes outlined between 7′ and 12′ girth inclusive and 20′ and 40′ height inclusive are based upon a sufficient number of trees to be really dependable. Volumes of other classes are based on only a few trees and obtained mainly by graphic interpolation and extension.

* Progress Report of Forest Research, Madras, 1928–29.

The following Provisional volume table was prepared by M. V. Laurie for the Mount Stuart forests, Madras.

Terminalia paniculata.—Provisional volume table in mixed forest, Mount Stuart, South Coimbatore, Madras*.

Breast height girth class in feet	Length of merchantable bole in feet												
	10	15	20	25	30	35	40	45	50	55	60	65	70
3– 4	6	9	12	14	16	18	19	20	22	24	25	26	..
4– 5	10	14	18	22	26	28	30	33	36	40	43	44	45
5– 6	13	19	25	30	36	41	44	47	51	55	58	60	61
6– 7	17	25	33	41	47	53	57	63	67	71	76	79	82
7– 8	22	32	43	52	62	69	78	86	92	98	104	107	109
8– 9	26	40	52	64	76	86	97	107	115	122	128	132	134
9–10	31	48	62	76	90	103	116	128	138	147	153	157	159
10–11	36	56	78	97	118	131	151	161	176	180	186	191	193
11–12	48	71	97	125	148	169	184	193	204	212	220	223	226
12–13	56	86	118	148	178	192	207	218	228	236	241	251	255
13–14	67	101	136	164	190	208	222	238	249	259	268	274	279
14–15	78	115	148	177	203	221	238	253	266	277	284	289	294

(Deduced from the Provisional Teak Volume Table by factors derived from the tree-volume figures given in Mr. Wood's Working Plan).

The following table was compiled from the district records of the North Mangalore forest division, Madras†.

Terminalia paniculata : *Volume table*

Girth class in inches	Number of trees	Total volume in cubic feet	Average volume in cubic feet
37– 42	2	28	14·0
43– 48	60	1,119	18·6
49– 54	189	3,646	19·0
55– 60	286	6,501	22·7
61– 66	200	5,344	26·7
67– 72	163	4,899	30·0
73– 78	87	3,032	35·0
79– 84	53	2,061	39·0
85– 90	28	1,114	40·0
91– 96	25	1,229	49·1
97–102	25	911	36·5
103–108	8	519	64·9

* Revised Working Plan for the Mount Stuart forest, South Coimbatore division, Madras, by M. V. Laurie, 1933, p. 171.

† Working Plan for the North Mangalore Forest division, Madras, 1934, pp. 56–57.

Curves were drawn showing the net average volume per tree against the corresponding girth class and volumes were read off the curves for each girth class. The table given below shows the actual outturn of that portion of the tree which would ordinarily be removed from the forest. The figures represent the volumes of round logs. The outturn figures depend for their accuracy on the number of trees taken for obtaining the average. The italicized figures represent the average obtained from more than thirty trees ; the other figures have been obtained from a comparatively smaller number of trees and so should be applied with caution.

Girth at breast height in inches	Volume in cubic feet of converted timber
36	12
42	*14*
48	*17*
54	*21*
60	*24*
66	*28*
72	*32*
78	*36*
84	*41*
90	46
96	51
102	57
108	64

The following volume outturn figures are from the Working plan for the Mangalore forest division, Madras, prepared by P. W. Davis, 1934.

Terminalia paniculata : *Volume outturn tables*

Girth class in feet	Volume of converted timber in cubic feet
	c. ft.
2– 3	8
3– 4	13
4– 5	21
5– 6	30
6– 7	40
7– 8	51
8– 9	..
9–10	..
10–11	..

Utilization – Supplies—Large quantities of this timber are available in the forests of the west coast the tree being among the commonest species found here in some forests. The total annual yield from these forests has been put at 10,000 to 12,000 tons, as detailed below :—North Kanara and Belgaum—1,000 tons, Satara division—500 tons, South Mangalore—750 tons, South Malabar—1,000 tons, South Coimbatore division—about 500 tons, Mysore—about 800 tons, Travancore-Cochin—1,000 tons. Large quantities of the timber are shipped from the west coast ports to Bombay, and the timber is stated to be steadily gaining in repute for building purposes. (Pearson and Brown).

The agency of exploitation is generally departmental, less frequently contractors to whom the trees are sold standing. Timber felled in Bombay and Madras forests off the foothills of Western Ghats finds its way to ports by means of carts or lorries or is floated down the rivers running westward to various harbours like Bhatkal, Kumta, Mangalore, whence they are taken to Bombay. Indirectly, also, timber sold in the sale depots is mostly transported by purchasers to the nearest harbours and shipped to Bombay, which is the principal market.

Description and general properties of the timber—The wood of *Terminalia paniculata* is grey, tinged with yellow when freshly cut. The heartwood is darker than the sapwood and on the lateral surface streaked with lighter coloured bands representing the spring wood. The wood turns dark with age, is rather lustrous, has a fairly smooth feel, and has no characteristic odour or taste. It is moderately heavy, the specific gravity being about 0·75 and straight grained.

Mechanical properties—Air-dry wood weighs 52 to 56 lbs. per c. ft. (R. S. Pearson). Its weight is given as 48 lbs. at 12% moisture content. In an air-dry condition this timber would be equal in transverse strength and elasticity to Burma teak, but considerably harder and stronger than that species in shear.

Seasoning properties—The value of this timber, like those of the *Terminalias* in general, depends largely upon proper seasoning. Any form of seasoning in the log, on land, results in excessive cracking, but better results are obtained by keeping the timber in water for some months. The best method seems to be green conversion and seasoning for 12 to 18 months in open stacked piles, but probably even better results can be obtained by green conversion, followed by immersion in water for 2 to 3 months and then seasoning in open stacks under cover. (Ind. For. Rec., VII, Pt. i, p. 21). It kiln seasons with practically no degrade if put in when quite green.

Durability and adaptability to treatment—The timber is durable under cover, and moderately so in the open or in contact with the ground. The life of a sleeper is 5 to 10 years (For. Bull. No. 48, F.R.I. 1922, p. 6). It is durable under water but refractory to antiseptic treatment.

Working qualities—The timber is not difficult to saw, especially when green. It is a little difficult to plane but otherwise machines well, though it is coarse-fibred. It finishes to a good shiny surface and takes good polish. Best results are obtained by eliminating the heart during conversion.

Uses – present and prospective—The wood is primarily used in building construction and owing to its cheapness it is getting more and more popular. Its chief use is for beams and rafters, though in Madras, Travancore and Cochin, doors and windows are also made out of it. In the Kolar gold mines it is put into various uses like side shafts for props, for ladder posts, props in the galleries, etc. It is also used in furniture, ship-building, dug-outs, boats, water troughs (South Vellore), mould frames (Mangalore) and in considerable quantities for agricultural implements. The Southern Railways use this timber for waggon doors, flooring and platform trucks. There seems to be little doubt that, when properly seasoned and treated

with preservatives, it would be a very suitable sleeper-wood, as it is hard, strong and fairly durable. In places where it attains but small sizes, near the limits of its geographical distribution, the wood is used for fuel and charcoal. It has been found suitable for manufacturing tea-chest and general second class commercial plywood. (Ind. For. Bull., Silviculture, n.s., No. 162, 1952). In Travancore a belief is current among the village people that tigers do not attack cattle in sheds built of this timber.

Minor Products—The bark gives a tannin. The branches are lopped for leaf-manure.

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INDIAN TIMBERS FOR SLATE FRAMES

BY M. A. REHMAN, JAI KISHEN AND M. L. MEHRA

General—After an examination of the claim of the indigenous slate industry for protection, the Indian Tariff Board made several recommendations to the Ministry of Commerce and Industry in 1949. One of these recommendations was that "The Provincial Forest Departments should undertake research in co-operation with the Forest Research Institute, Dehra Dun, regarding the availability of suitable types of wood in each Province, for the manufacture of slate frames". In pursuance of this directive the States of Bombay and Madhya Pradesh sent samples of several timbers to the Forest Research Institute for test, the results of which are given in this publication, along with some useful information on the slate industry.

History of slate industry—The manufacture of stone slates was first started at Markapur in Kurnool District of Madras in 1918 on a small cottage scale. The industry considerably expanded up to World War II, and a large number of factories came into existence. During the World War II the import of slates fell and the indigenous industry made rapid strides. The quality of the indigenous product also improved, and in some factories machinery and power came to be used to modernize the manufacturing processes. In addition to Markapur, Cumbum and Gajjalakonda, also in Kurnool District, became the chief centres of production. The industry established itself in other places also where slate stone was available nearby, viz., Bijapur District, in Bombay Province, Ateli in PEPSU., and Kund in East Punjab. The manufacture of slates in Ateli and Kund began at about the same time as at Markapur. It is estimated that there are about two hundred stone slate making factories in the country. In addition there are about 15 factories making metal slates, which industry was started about 1930. Prior to that the metal slates were largely imported from Germany and France, and to some extent from Italy and Japan. Most of the metal slate factories are located in Delhi and its neighbourhood and there are also a few factories in South India, in places like Ogalewadi and Bangalore. The total production of slates is estimated at about 4 crores per year. A small quantity of slates is exported to Burma, Ceylon, Malaya, South Africa and Pakistan.

Requirement of timber for slate frames—Wood is an important raw material used by the slate industry for making the frames. The frames are of two types, viz., the clutch type and the machine-round-tin (m. r. t.) type. In the case of the former there is a tongue and groove joint at the corners, whereas the latter type of frame has rounded corners which are covered with small srtips of tins. The first quality slates are of the clutch type only, while the second quality slates are made both in clutch and m. r. t. varieties. All slates produced in a factory are not of the first qulity. Those that fall below this standard are called "seconds" and form 20 to 30% of the tatal out-put of the factory depending upon the manufacturer.

The requirements of timber are not exacting. The timber should be light in weight, combined with some degree of strength. It should be easy to saw, machine and work with hand. It should not chip or show raising of grain during planing, grooving and chamfering. Pleasing light colour is desirable and the timber should be able to withstand nailing. In addition the wood should be cheap and available in large quantities.

South India factories commonly use silver oak (*Grevillea robusta*), *booraga* (*Bombax malabaricum*), red *pala* (*Lophopetalum wightianum*), white *pala* (*Alstonia scholaris*) and *potiki* (*Gyrocarpus americanus*). The factories in North India use fir (*Abies pindrow*) and spruce (*Picea morinda*).

Manufacturing process for slate frames—The timber is first converted into long strips of desired width and thickness. These srtips are then seasoned in the open air for a few days (say three days to a week). These are grooved and chamfered and later cut into short pieces of required lengths. The short pieces so obtained are either tongued and grooved at the ends or their ends are cut for lap joints and finished with rounding and fitting of metal strips. The corners are glued or nailed depending upon the practice in the factory.

Result of tests—The timbers received from Bombay and Madhya Pradesh for this test in the form of small planks were first seasoned. They were then cut into strips which were planed, grooved and chamfered on machines. The behaviour of every timber during processing was recorded. The strips were then made into slate frames with tongue and groove and they were nailed. A summary of observations recorded is given in the following pages.

It may be pointed out that there are several Indian timbers found in practically every State, other than those tested in this investigation, which can be used for slate frames. These will be tested in due course. The timbers tested are classified below based on their behaviour :—

(a) *Timbers found suitable for first quality frames.*
Adina cordifolia (*haldu*).
Boswellia serrata (*salai*).
Chloroxylon swietenia (East Indian satin-wood).
Dysoxylum malabaricum (white cedar).
Gmelina arborea (*gamari*).
Gardenia spp. (*gardenia*).
Holoptelea integrifolia (*kanju*).
Holarrhena antidysentrica (*indra jau*).
Mitragyna parvifolia (*kaim*).
Tectona grandis (teak).
Trewia nudiflora (*gutel*).

(b) *Timbers found suitable for second quality frames.*
Artocarpus integrifolia (*kathal*).
Bombax malabaricum (*semul*).
Kydia calycina (*pula*).
Lannea grandis (*jhingan*).
Mangifera indica (mango).
Machilus macrantha (*machilus*).
Polyalthia fragrans (*gauri*).
Sterculia urens.
Terminalia belerica (*bahera*).

Description of timbers tested and observations recorded.

(a) *Timbers for first quality frames* :

Adina cordifolia (*haldu*)—*Haldu* can be used for high class and costly slate frames. It is a yellow coloured wood with fine even texture. It can be seasoned easily with a little protection against sun and hot winds. It possesses fine working qualities. It is an easy wood to saw and machine, and it can be easily worked to smooth finish. No raising of grains or splitting was observed while planing, grooving and chamfering. Slight splitting while nailing was observed. *Haldu* is found scattered throughout the deciduous forests of India, particularly in Uttar Pradesh, Madhya Pardesh, Bengal, Bihar, Orissa, Bombay and Madras.

Boswellia serrata (*salai*)—*Salai* is suitable for good quality slate frames. It is a light timber which can be seasoned easily but is liable to blue stain. It gives no difficulty in sawing

and machining. It is an easy wood to work with hand. No raising of the grain or splitting was noticed while planing, grooving and chamfering. There was no splitting while nailing. It is available in Madhya Pradesh, Madras, Bombay, Bihar, Orissa and in certain parts of the Uttar Pradesh.

Chloroxylon swietenia (East Indian satin-wood)—East Indian satin-wood is a first class timber for slate frames. It is a hard, yellowish coloured wood having very small pores. It requires good protection against rapid drying to give satisfactory results. Regarding durability it is one of the best timbers and possesses very fine working qualities. It is easy to saw and machine and can be easily brought to a smooth finish. No raising of the grain or splitting was observed during planing, grooving and chamfering. It does not crack while nailing. It is available in Central and Southern India.

Dysoxylum malabaricum (white cerdar)—White cedar is a good quality timber suitable for costly types of slate frames. It is a light-coloured brownish grey wood with a fine texture. It can be easily seasoned without any trouble or degrade. Sapwood is liable to blue stain. It is a moderately heavy timber having the same strength as teak. It saws and works with ease to a fine finish and presents no difficulties in working with hand. No raising of the grain or splitting was observed during planing, grooving and chamfering. It does not crack while nailing. Only small supplies are available on the West Coast, Madras, Coorg and Mysore.

Gmelina arborea (*gamari*)—*Gamari* is a first class timber for slate frames. It is a close-textured wood with a smooth feel. It can be easily seasoned without any degrade but takes a long time to season when radially cut. A light strong wood which is easy to saw and machine and can be easily worked to a good finish. No raising of the grain or splitting was observed during planing, grooving and chamfering. No splitting while nailing was observed. It has got a slight tendency to warp after assembly. It is available from Bengal, Assam, Madhya Pradesh, Bombay, Orissa and Uttar Pradesh. Supplies are not abundant.

Gardenia spp. (*gardenia*)—*Gardenia* is a superior wood and it should be used for high class slate frames. It is a pale creamy wood with very fine texture. It can be easily seasoned with a little protection against sun and hot winds. In spite of being hard and tough, it is not difficult to saw and plane and gives a very smooth finish. No raising of the grain or splitting occurs during planing, grooving and chamfering. No splitting while nailing was observed. It is one of the best turnery timbers. Limited supplies of *gardenia* are obtained from Madhya Pradesh, Bombay, Uttar Pradesh and Bihar.

Holoptelea integrifolia (*kanju*)—*Kanju* is suitable for good quality slate frames and is already used for this purpose. It should be dried rapidly to avoid blue stain and mould. It is easy to saw and machine and can be easily worked to a clean finish. No raising of the grain or splitting was observed while planing, grooving and chamfering. It does not split while nailing. Large supplies of *kanju* are available from Uttar Pradesh. It is also available in Bihar, Orissa and Madhya Pradesh.

Holarrhena antidysentrica (*indra jau*)—*Indra jau* is a first class timber for slate frames. It is a soft, white coloured wood having straight grain. It presents no difficulty in seasoning. It is an easy wood to saw and machine and can be easily worked with hand. It becomes quite smooth after planing. No splitting or raising of the grain was observed during planing, grooving and chamfering. There was no splitting while nailing. It is also a first class turnery timber. It is available in sal forests of Northern and Central India.

Mitragyna parvifolia (*kaim*)—*Kaim* should be used for high class slate frames. It is light brown in colour with fine even texture and smooth feel. It can be easily seasoned but needs a little care and protection against rapid seasoning. It is easy to saw and machine

and works to a smooth finish. No splitting or raising of the grain was noticed during planing, grooving and chamfering. It has got good nail holding properties for which reason it is used for boot lasts. It is found scattered in Uttar Pradesh, Bihar, Bombay, Madras and Orissa.

Tectona grandis (teak)—Teak should be used for superior quality slate frames. It is easy to season with usual precautions. It is a coarse textured wood. It is an easy wood to saw and machine and can easily be worked by hand. No raising of the grain or splitting was observed while planing, grooving and chamfering. No splitting while nailing. It is available in Madras, Bombay, Madhya Pradesh, Orissa, Bengal, Coorg. (Offcuts of logs and waste-wood in the saw-mills can, with advantage, be used for this purpose).

Trewia nudiflora (*gutel*)—*Gutel* is a first class timber for slate frames. It is a straight grained timber with medium fine texture. It can be easily seasoned without any degrade but it is prone to blue stain. Sapwood should not be used for slate frames if discoloured. It is easy to saw and machine and can be easily worked to a nice smooth finish. No raising of the grain or splitting was noticed while planing, grooving and chamfering. It does not split while nailing. *Gutel* is chiefly obtained in good quantities from Uttar Pradesh, Bengal and in limited supplies it is available from Bombay and Assam.

(b) *Timbers for second quality frames* :

Artocarpus integrifolia (jack)—Jack is a second class timber for slate frames. It is yellow in colour, unusual for slate frames. It is a coarse textured wood. It can be easily seasoned without any trouble or degrade. It is an easy wood to work and presents no difficulties in working with hand or machine but its surface remains slightly rough after planing. There was no raising of the grain or splitting while planing, grooving and chamfering. It does not split while nailing. It has got slight tendency to warp after assembly. Small streaks of siliceous deposits were observed, which spoil the cutter and saw while planing and cutting. It is obtained chiefly from Madras and Bombay.

Bombax malabaricum (*semul*)—*Semul* should be used for cheap quality slate frames. It is a soft, weak and highly perishable wood and prone to blue stain. It is creamy white timber having large open pores. It dries very rapidly without any degrade. It is one of the easiest timbers to saw and work but its surface remains slightly rough due to its wide pores after planing. No splitting or raising of the grain was observed during planing, grooving and chamfering. It does not crack while nailing. It is a very light timber generally used for all types of packing cases and match box manufacture. It is available almost in every State in India except East Punjab.

Kydia calycina (*pula*)—*Pula* is good for ordinary class of slate frames. It is white in colour having wide pores. It is a softwood and can be normally seasoned free from cracks. It is an easy wood to saw and machine and presents no difficulties in working with hand. On the whole the finish is poor. Raising of the grain was observed while grooving and chamfering. It cracked a little while nailing. It is available in the deciduous forests throughout India, not in arid region.

Lannea grandis (*jhingan*)—Considering sapwood and heartwood together *jhingan* can be used for second class slate frames. Colour of sapwood is whitish and colour of heartwood is brownish red. Heartwood is very slow to season, whereas sapwood is easy to season, but it is liable to blue stain and is perishable. Sapwood is not durable whereas heartwood is durable to a good degree. It is an easy wood to saw and work. It can be turned to a good finish but sometimes it creates a lot of trouble in sawing due to the presence of gum in it. No raising of the grain or splitting was observed during planing, grooving and chamfering. There was no cracking while nailing. It is available in limited quantities from Uttar Pradesh, Madhya Pradesh, Bengal, Bihar, Orissa and Madras.

Mangifera indica (mango)—Mango is a good second class timber for slate frames. It is a greyish brown timber having wide pores and is coarse textured. It presents no difficulties whatsoever while seasoning. It is an easy wood to saw and machine and can be easily brought to a smooth finish but it is not very durable. It is liable to blue stain and insect attack. There was no raising of the grain or splitting while planing, grooving and chamfering. It can stand nailing. It is found everywhere in India but the supplies in any one locality are not much.

Machilus macrantha (*machilus*)—This timber is also suitable for cheap quality slate frames. It is orange brown in colour having wide pores. It is liable to discolouration. It is an easy wood to season, saw and machine but the finish is slightly rough. It splits while chamfering. No splitting while nailing was observed. It is available in the Western Ghats.

Polyalthia frangrans (*gauri*)—*Gauri* is a second class timber for cheap quality slate frames. It is greyish white, moderately hardwood and liable to discolouration. Easy to season, saw and machine but finish is not smooth. It splits while chamfering. No splitting while nailing was observed. It is available from S. Konkan, Kanara and Malabar.

Sterculia urens—It is a second class timber for cheap quality slate frames. It is reddish brown in colour which is not pleasing to look. It is very light and weak timber and is not durable. Extremely easy to season, saw and works to a smooth finish. It can easily stand nailing. It is available in dry forests of North India, Central India, Deccan and West Coast.

Terminalia belerica (*bahera*)—*Bahera* is a second class timber for slate frames. It is greyish yellow in colour. Not pleasing to look. It is a wide pored timber with a very coarse texture. It can be easily seasoned without any difficulty or degrade but it is liable to fungus and insect attack. Not very durable. It is an easy wood to saw and machine and presents no difficulties in working with hand but its surface remains rough due to its coarse texture. There was no splitting or raising of the grain while planing, grooving and chamfering. It does not split while nailing. It is available from Bombay, Madras, Assam, Bengal, Uttar Pradesh and Madhya Pradesh.

(c) *Timbers found unsuitable* :

Out of the timbers tested in this investigation, the following two timbers were found unsuitable for slate frames :—

(i) *Sterculia villosa*—It is not suitable for slate frames due to its poor finish and being very light and weak. It is prone to fungus attack and is perishable.

(ii) *Zanthoxylum rhetsa*—This timber is brittle and it is not recommended for slate frames due to splitting while nailing and also during chamfering.

RESULTS OF AN EXPERIMENT TO STUDY THE SUCCESSION OF GROUND FLORA SPECIES UNDER FOREST PLANTATIONS RAISED ON OLD AGRICULTURAL LAND IN THE NEW FOREST, DEHRA DUN, INDIA

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(*Continued from* Indian Forester, *September 1954, page 530*)

GMELINA ARBOREA PLANTATIONS

Stumps of *Gmelina arborea* prepared from seedlings raised from Chittagong origin seeds were planted in 1926 at 6 × 6 feet espacement. One 15 × 15 feet ground flora quadrat was laid out in 1928.

In 1934, some plants of *Gmelina* were attacked by a fungus and died, but later on the canopy closed up again. In 1936, the experiment was concluded.

The ground flora species are given in Table 7.

The ground flora vegetation consists of *Ageratum conyzoides* community with a fairly high frequency throughout the period of observations. The frequency of *Ageratum* showed a decrease from 56% in 1932 to 49% in 1933. In 1934, it increased again due probably to *Gmelina* plants having become leafless by fungus attack. Its frequency, however, again declined in 1935, when probably the canopy closed up a little.

The other notable species in the community, in 1932, were *Andropogon muricatus* and *Scoparia dulcis*. The frequency of the former increased but of the latter showed a decline from 1932–35. In 1935, the total number of species in the community was 30, as compared to only 8, in the beginning. Another noticeable feature in this quadrat was the occurrence of seedlings of a number of tree species, the majority of which appeared in 1935, after the forest floor had gained some humus, etc. The coming in of forest tree seedlings in the plantations may be due to the soil factor as well as to better dispersal mechanism of species that occur in the neighbouring area. Of the species present in the quadrat *Bombax* has wind dispersed seeds. Pods of *Dalbergia* being light are also dispersed by wind and this is a well known early colonizer on disturbed lands. *Eugenia, Psidium, Rhamnus,* and probably *Cedrela* and *Litsea* are dispersed by birds and small animals. The superior seed dispersal mechanism of these species may have helped them in their invasion of these plantations.

TECTONA GRANDIS PLANTATIONS

The plantations of *Tectona grandis* were raised in 1928 by planting stumps at 6 × 6 feet espacement. In 1931, one quadrat of 15 × 15 feet was demarcated in comptt. 38. The frequency of ground flora species was recorded in 1932. In September 1933, teak plants were defoliated by *Hapalia machaeralis*. In 1934, all teak plants were killed back by frost. Frequencies were again recorded but teak canopy did not close up much as it was badly affected again by 1935 frost. At the time of the conclusion of the experiment in 1936 the height of teak was only 6 to 10 feet.

TABLE 7

Frequencies of different species as the percentage of the total number of species in a quadrat of Gmelina arborea (old), laid in compartment 10

Serial No.	Condition of trees on given dates			*Gmelina* plants attacked by fungus and plants became leafless	Canopy closed up again
		29–9–32	3–10–33	9–9–34	22–9–35
1	*Ageratum conyzoides* ..	56·6	49·2	63·4	35·4
2	*Andropogon muricatus* ..	8·0	16·7	16·1	15·2
3	*Apluda aristata*	..	..	..	1·1
4	*Artocarpus* sp.	..	..	..	0·6
5	*Bidens pilosa*	..	0·8	2·1	0·6
6	*Bombax malabaricum* seedlings	..	..	..	0·6
7	*Bothriochloa pertusa* ..	..	..	..	1·7
8	*Cedrela toona* seedlings ..	..	..	..	1·7
9	*Cynodon dactylon*	..	..	..	1·1
10	*Cyperus rotundus*	..	..	..	0·6
11	*Dalbergia sissoo* seedlings ..	0·9	1·6	2·1	1·7
12	*Dichanthium annulatum* ..	..	13·5	3·2	6·2
13	*Eugenia jambolana* seedlings ..	15·0	0·8	1·1	1·7
14	*Euphorbia geniculata* ..	0·9	4·8	2·1	1·1
15	*Euphorbia hirta*	5·3	..	..	..
16	*Jasminum pubescens* seedlings ..	..	..	..	1·7
17	*Litsea polyantha* seedlings ..	..	..	..	5·0
18	*Murraya koenigii* seedlings ..	..	..	..	2·8
19	*Paspalum scrobiculatum* ..	..	..	..	0·6
20	*Psidium guava* seedlings ..	..	0·8	..	1·7
21	*Rhamnus virgatus* seedlings ..	..	..	..	0·6
22	*Rottboellia compressa* ..	..	0·8	..	1·7
23	*Saccharum spontaneum* ..	..	..	..	0·6
24	*Scoparia dulcis*	8·8	3·2	1·1	..
25	*Setaria glauca*	..	..	..	0·6
26	*Sida rhombifolia*	4·4	7·1	4·3	1·7
27	*Bothriochloa pertusa* ..	..	..	..	1·7
28	*Tephrosia candida*	..	..	3·2	6·2
29	*Triumfetta rhomboidea* ..	..	0·8	1·1	3·4
30	*Urena lobata*	..	..	..	1·1
31	*Ventilago calyculata* ..	..	..	..	1·1
32	*Zizyphus jujuba* seedlings ..	..	..	..	0·6

The frequency of ground flora species is recorded in Table 8. The ground flora consists of *Ageratum conyzoides* community in which *Setaria glauca* formed no less than 27% in the beginning. But after the first record the species disappeared.

TABLE 8

Frequencies of different species as the percentage of the total number of species in a quadrat of Tectona grandis laid in compartment 38 in 1931

Serial No.	Species	24–9–1932	23–9–1933	30–9–1934	24–9–1935
1	*Ageratum conyzoides* ..	43·3	50·0	67·2	26·2
2	*Alysicarpus rugosus* ..	..	..	..	0·8
3	*Andropogon muricatus* ..	..	0·9	3·2	0·4
4	*Apluda aristata*	..	..	..	1·7
5	*Artemisia vulgaris*	4·7	7·3	4·9	5·9
6	*Bidens pilosa*	..	..	..	2·5
7	*Cedrela toona* seedlings ..	11·3	7·3	8·2	10·5
8	*Cissampelos pareira* ..	..	..	..	0·4
9	*Corchorus olitorius*	..	..	..	0·8
10	*Cynodon dactylon*	0·7	..	..	..
11	*Dalbergia sissoo* seedlings ..	..	..	..	0·8
12	*Dichanthium annulatum* ..	..	1·8	..	2·1
13	*Erigeron linifolius*	..	3·6	..	..
14	*Eugenia jambolana* seedlings ..	0·7	0·9	..	0·4
15	*Euphorbia geniculata* ..	..	..	..	5·0
16	*Euphorbia hirta*	4·0	..	..	0·4
17	*Imperata cylindrica* ..	6·7	9·0	8·2	26·2
18	*Justicia simplex*	..	..	..	0·8
19	*Oxalis corniculata*	..	..	..	0·4
20	*Paspalum royleanum* ..	..	8·2	..	..
21	*Paspalum sanguinale* ..	..	..	..	1·3
22	*Paspalum scorbiculatum* ..	(Data not clear)	8·2	1·6	..
23	*Phyllanthus urinaria* ..	..	..	..	1·7
24	*Rottboellia compressa* ..	..	..	1·6	..
25	*Rubus* sp. seedlings ..	..	..	..	0·4
26	*Saccharum spontaneum* ..	..	..	..	0·8
27	*Setaria glauca*	27·3	..	..	..
28	*Sorghum halepense*	1·3	2·7	3·2	9·3
29	*Urena lobata*	..	..	..	0·4

The frequency of *Ageratum* increased in 1933–34, due probably to the defoliation of teak plants, and reduction in canopy by frost in 1934. By 1935, when the canopy closed a bit, frequency of *Ageratum* decreased again.

The noticeable feature in this quadrat is the increase from 1932 onwards in the frequency of *Imperata cylindrica* and *Sorghum halepense*. Towards the close of the experiment, tree seedlings became somewhat conspicuous.

Seasonal variations in the frequency of ground flora species were found in these plantations as well. The variation is not very significant in the beginning, but by the progress of

the tree vegetation and the development of distinct light and shade conditions during various months of the year and other changes in the soil, the same ground flora species began to exhibit a distinct periodicity. This is manifested in the data from other quadrats as well. The details have not been reproduced here to save space.

Another quadrat was laid out in the teak plantations in comptt. No. 15. The ground flora vegetation, as seen in Table 9 was formed by *Ageratum-Erigeron* community. In 1931, teak was cut back having been damaged by frost. Frequency of ground flora was recorded in 1932. In 1934, teak was again cut back. By this time, the quadrat had been heavily invaded by *Imperata cylindrica*. Teak was again frosted in January 1935 by which time *Imperata* had grown 3 feet high and had covered the ground thickly. In 1937, teak was only about 9 feet high, having been frosted and cut back several times, and *Imperata* had become tall and conspicuous. The quadrat was closed in 1939.

The frequency of *Ageratum* increased considerably in 1933–34, but the heavy growth of *Imperata cylindrica* now changed the entire structure of the community which appeared *Imperata-Ageratum* community. *Imperata* became 3 feet tall and tended to suppress *Ageratum*, whose percentage showed a decline. Between 1932 and 1935, *Dichanthium annulatum* became very prominent in the ground flora community. Seedlings of a number of tree species became prominent after 1936.

The areas thereafter were abandoned and other species were planted. Bamboos in comptt. No. 38 and *Acrocarpus* in comptt. No. 15 and hence no information can be given from these comptts. in particular. In other compartment, where teak has been successful, there is absolutely no *Imperata* which has altogether disappeared from under teak.

SHOREA ROBUSTA PLANTATIONS

The plantations of *Shorea robusta* were raised by sowing, local seed, in lines 8′ apart. In 1928, one 15′ × 15′ quadrat was laid out in comptt. 20. The ground flora species are given in table 10.

The community is dominated in the beginning by *Ageratum conyzoides* and *Erigeron linifolius*. By May 1930, *Dichanthium annulatum* and *Cynodon dactylon* appeared throughout the quadrat. The area was invaded in September of the same year by small colonies of *Imperata*, *Ageratum* and *Erigeron*, which was mainly covered with *Dichanthium*, existing in a suppressed state. By 1931, *Imperata* had become more marked and by the end of September 1932, this had almost ousted *Dichanthium* and *Erigeron*. During the next few years, both *Dichanthium* and *Erigeron* became absent, except during 1936–37, when *Dichanthium* was again recorded. In September 1933, the frequency of *Ageratum* had greatly declined. *Dichanthium* has disappeared and *Imperata* had become very abundant.

It has been recorded that frost killed back sal plants in April 1934 and by September the tree canopy was greatly reduced. The ground flora continued to be dominated by *Imperata* in which some plants of *Rottboellia* had become prominent. By September 1935, *Imperata* had become 3′ high and covered the whole of the comptt. In 1935, although, the canopy of sal had greatly reduced, saplings of *Dalbergia sissoo* grew up sufficiently tall to close up the canopy. In 1936, *Imperata* was still quite heavy and some seedlings of *Cedrela toona* had appeared. During all these years, some plants of *Rottboellia* were present, but afterwards this species vanished. In 1938, *Imperata* was still the dominant species among the ground flora, although the percentage of *Ageratum* had somewhat increased. Several other species, *Oxalis corniculata*, *Oplismenis compositus*, *Nepeta ruderalis*, *Justicia simplex*, *Cissampelos pareira*, *Rubus lasiocarpus*, had now appeared among the ground vegetation.

TABLE 9—*Frequencies of different species as percentage of the total number of species in a quadrat of Tectona grandis laid out in compartment 15*

Serial No.	Species	Sept. 1930	20-9-1932	Sept. 1933	30-9-1934	22-9-1935	20-9-1936	1937	29-9-1938
1	*Ageratum conyzoides* ..	18·8	36·5	53·5	45·7	13·9	3·7	26·9	23·3
2	*Ajuga bracteosa* ..	..	..	..	..	..	4·3	1·8	..
3	*Alysicarpus rugosus* ..	10·7	..	..	..	2·8	..	..	..
4	*Andropogon muricatus* ..	..	..	..	..	0·4	..	0·6	..
5	*Apluda aristata* ..	..	..	..	..	1·2	..	0·9	..
6	*Atylosia platycarpa* ..	3·3	..	..	..	..	0·9	1·8	..
7	*Artemisia vulgaris* ..	..	..	0·8	..	2·4	2·5	14·9	15·9
8	*Bidens pilosa* ..	..	..	..	..	11·9	1·5	1·5	0·2
9	*Bothriochloa pertusa* ..	..	8·7	11·8	5·7	8·4	1·2	..	..
10	*Cassia tora* ..	..	..	..	..	0·8	..	..	..
11	*Cedrela toona* seedlings ..	2·5	..	0·8	4·3	0·8	14·8	2·6	2·0
12	*Cissampelos pareira* ..	..	..	..	..	..	0·6	..	0·4
13	*Cymbopogon martini* ..	..	..	..	..	..	0·6	1·2	..
14	*Cynodon dactylon* ..	..	..	..	..	0·4	..	..	..
15	*Cynoglossum lanceolatum* ..	2·5	..	..	..	..	..	..	..
16	*Dalbergia sissoo* seedlings ..	..	..	..	..	2·4	1·2	1·8	0·4
17	*Desmodium polycarpum* ..	..	..	2·4	1·4	3·2	4·9	4·9	1·6
18	*Desmodium triflorum* ..	..	..	..	..	2·8	6·2	..	..
19	*Dichanthium annulatum* ..	..	22·2	12·6	4·3	6·8	0·3	..	..
20	*Dioscorea* spp. ..	..	..	..	..	..	0·3	0·6	0·7
21	*Erigeron linifolius* ..	36·9	..	..	..	..	..	..	..
22	*Eugenia jambolana* seedlings	..	..	..	..	0·4	..	..	1·3
23	*Euphorbia geniculata* ..	9·0	18·3	..	..	0·4	..	..	..
24	*Euphorbia hirta* ..	2·5	3·9	..	..	1·2	0·6	0·3	..
25	*Imperata cylindrica* ..	1·6	5·6	14·1	*38·6*	*25·0*	16·1	18·5	14·3
26	*Indigofera tinctoria* ..	..	..	3·9	..	5·6	10·2	3·5	2·5
27	*Justicia simplex* ..	..	..	..	..	..	15·1	1·2	10·8
28	*Litsea polyantha* seedlings ..	..	..	..	..	..	0·3	..	0·9
29	*Mallotus philippinensis* seedlings ..	..	..	..	..	..	0·3	0·3	0·2
30	*Murraya koenigii* seedlings ..	..	..	..	..	0·4	..	..	..
31	*Nepeta ruderalis* ..	..	..	..	..	..	1·5	1·8	0·9
32	*Oxalis corniculata* ..	..	..	..	..	..	3·5	8·2	16·1
33	*Phyllanthus urinaria* ..	..	..	..	..	1·2	2·5	0·3	1·1
34	*Psidium guava* seedlings ..	..	..	..	..	..	..	..	0·2
35	*Rottboellia compressa* ..	1·6	..	..	..	..	..	..	..
36	*Rungia repens* ..	..	..	..	..	..	..	..	0·9
37	*Saussurea candicans* ..	..	..	..	..	..	..	..	1·6
38	*Sesbania* spp. ..	..	..	..	..	..	0·6	0·6	..
39	*Setaria glauca* ..	..	..	..	..	1·5	..	..	..
40	*Sida rhombifolia* ..	7·4	2·4	..	..	1·2	1·2	..	..
41	*Sonchus arvensis* ..	..	..	..	..	..	..	0·6	..
42	*Sorghum halepense* ..	3·3	2·4	..	..	..	..	..	1·1
43	*Urena lobata* ..	..	..	..	..	4·8	5·2	4·7	2·0
44	*Zizyphus jujuba* seedlings ..	..	..	..	..	..	..	0·6	0·9

In September 1939, *Ageratum* has become prominent again, and the growth of *Imperata* tended to become poor and after 1941, this species had disappeared. The ground flora was now mostly composed of dicotyledonous species, with little, or no, coarse grasses. The only grass which later gained importance was *Oplismenus*, the frequency of which increased from year to year. By 1944, *Oplismenus* was the most important species in the ground flora, with some *Ageratum*. In 1945, *Ageratum* had more or less disappeared and *Oplismenus* and seedlings of a number of shrub species were the only ground flora species. By 1948, *Ageratum* had again become prominent.

There is an interesting periodicity in the frequencies of several ground flora communities during May–July and September.

In comptt. No. 18, where sal was sown in lines in 1926, one quadrat $16\frac{1}{2}' \times 16\frac{1}{2}'$ was demarcated in 1931. The ground flora species are given in table 11.

In the beginning the ground vegetation was dominated by *Ageratum conyzoides, Dichanthium annulatum* and *Cynodon dactylon* in which seedlings of *Dalbergia sissoo* were present. In September 1933, *Ageratum* had become more abundant along with *Dichanthium*. In 1934, sal plants were cut back, having been injured by frost. Saplings of *Dalbergia sissoo* were also cut back but these had coppiced vigorously and by September 1934 became 8′–9′ high, while the three sal plants had attained the height of only $3\frac{1}{2}'$, $4\frac{1}{2}'$ and $6\frac{1}{2}'$, respectively.

A noticeable feature in the ground flora was the invasion of the community by *Imperata*. In September 1935, although sal had become leafless by an insect attack, vigorously growing plants of *Dalbergia sissoo* maintained a closed canopy. *D. sissoo* had reached a height of 12′, and though *Ageratum* had decreased, *Imperata* had considerably increased. *Cynodon dactylon* has also become conspicuous. By September 1936, *Dalbergia sissoo* had become more important in the canopy than sal and in 1937, *Ageratum* had grown as high as 3′, covering most of the area.

Another interesting species which has been recorded only from this quadrat is *Clerodendron infortunatum*, the frequency of which has been increasing with some fluctuations after 1936. The presence of *Oplismenus compositus, Oxalis corniculata, Jasminum* and seedlings of *Murraya, Litsea polyantha, Eugenia jambolana* and *Cedrela toona* had become noticeable in the ground flora as forest conditions had established. Coarse grasses like *Imperata, Dichanthium* and *Cynodon* considerably decreased under closed canopies.

PINUS LONGIFOLIA PLANTATIONS

Plantations of *Pinus longifolia* were raised by sowing seeds of different orgin, in lines, 6′ apart. Comptt. 41 was raised from Lansdowne seed and one quadrat $15' \times 15'$ was marked for study in 1931. The ground flora species are given in table 12.

The ground flora vegetation in 1932 was dominated by *Ageratum conyzoides, Imperata arundinacia,* and *Artemisia vulgaris. Dichanthium annulatum* was also well represented in the beginning but it disappeared soon afterwards. By 1933, *Imperata* had greaty increased and in 1934 it had occupied almost the entire area of the quadrat. *Ageratum* was present underneath *Imperata* and the percentage of *Artemisia* decreased considerably after 1932. By September 1935, *Imperata* had grown about 3′ high and canopy of the *chir* pine had considerably closed. A number of other species had sprung up later, of which *Desmodium triflorum, Cynodon dactylon, Sida rhombifolia* and *Phyllanthus urinaria* may deserve special mention.

By 1937, the canopy of the *chir* pine had covered the entire quadrat and the percentage of *Imperata* greatly decreased. By September 1938, *Imperata* had become rare and *Ageratum*

plants, which had become about 2½′ high by now, had become abundant. The number of other species had by now increased. In September 1939, *Ageratum* had again become abundant and *Imperata* seemed to be on the decline. Among the important tree species that had become conspicuous *Cedrela toona*, *Psidium guava* and *Dalbergia sissoo* may be mentioned. By 1944, *Oplismenus compositus* which had entered the community in 1938 had become quite common and *Imperata arundinacea* was replaced by *Imperata cylindrica*. Seedlings of *Morus alba* and *Murraya koenigii* had become quite common. By 1947, the community was formed by *Ageratum conyzoides* and *Imperata arundinacea* which had again appeared. *Oplismenus compositus* and several dicotyledonous species were present in the area.

One other quadrat 20′ × 20′ was laid out in 1928 in the plantation of *Pinus longifolia* that was raised from Chakrata seed in June 1926. The species are given in table 13.

The ground flora community is formed by *Ageratum conyzoides* – *Sorghum* in which *Dichanthium*, *Verbena officinalis* and *Erigeron linifolius* are other common species. *Verbena* disappeared soon after, and *Erigeron* also disappeared within three years, gradually. An interesting feature of this quadrat is the absence of *Imperata*. With the development of the tree canopy, the percentage of *Ageratum* increased till 1934 ; after which it fluctuated but never became as high as in September 1934. *Ageratum* was about 9″ high and covered the entire ground. By 1936, *Ageratum* had grown to 2½′ high and seedlings of *Cedrela toona*, *Eugenia jambolana*, *Litsea polyantha*, *Murraya*, etc., had appeared. *Rottboellia compressa* which had been present from the beginning began to disappear after 1936, when *Oplismenus compositus* entered the community and went on increasing in percentage. *Sorghum* also declined by about this time and a number of dicotyledonous species with low frequencies appeared.

By September 1937, *chir* pine had formed fairly closed canopy and *Ageratum* began to decline in frequency. After 1938, seedlings of *Broussonetia* entered the community and their frequency tended to increase under forest conditions. By 1943, *Ageratum* and *Oplismenus* had shared abundance but with the further development of the tree canopy *Oplismenus* gained over *Ageratum*.

A small part of comptt. 23 was set apart to study the changes that occurred in the ground flora vegetation on burning. A quadrat 20′ × 20′ was laid in March 1936 and the area was burnt satisfactorily in April 1936. It was again burnt in April 1937. The ground flora vegetation is given in table 14.

A comparison of the vegetation of the unburnt area given in table 13 with the burnt part in table 14 shows interesting changes in the growth and development of some of the ground flora species.

In the burnt area, the frequency of *Ageratum* greatly declined from 1936 to 1948, except in 1942. The percentage of *Sorghum halepense* increased in the burnt area. There was a considerable decrease in tree seedlings of *Cedrela toona*, *Eugenia jambolana* and *Broussonetia* in the burnt area. On the other hand *Zizyphus* and *Urena lobata* appeared only in the burnt quadrat. Although, the data are not quite clear, it seems that the growth of *Cynodon dactylon* and *Imperata* is favoured by burning. The growth and the progress of the finer grass *Oplismenus* and of *Murraya koenigii* greatly decreased in the burnt area.

TABLE 10.—*Frequencies of different species on the percentage of the total number*

Serial No.	Species	20–9–30	26–9–32	14–9–33	21–9–34	19–9–35	17–9–36	16–9–37
1	*Achyranthes aspera* ..	..	..	..	..	..	..	..
2	*Ageratum conyzoides* ..	28·0	54·0	28·4	16·9	8·4	11·4	14·4
3	*Ajuga bracteosa*	..	..	..	..	..	1·4	5·4
4	*Albizzia procera* seedlings ..	..	..	1·0	1·2	1·2	1·4	0·5
5	*Alysicarpus rugosus* ..	1·6	..	..	..	..	..	..
6	*Dichanthium annulatum* ..	..	19·0	..	..	..	1·4	3·1
7	*Sorghum halepense* ..	..	..	..	..	..	..	..
8	*Artemisia vulgaris* ..	..	..	..	..	1·2	..	..
9	*Atylosia platycarpa* ..	7·2	..	..	..	..	..	..
10	*Bidens pilosa*	..	..	..	..	1·2	2·1	1·7
11	*Bombax malabaricum* seedlings	..	..	..	..	..	..	..
12	*Broussonetia papyrifera* seedlings	..	..	..	..	..	..	..
13	*Cassia mimosoides* seedlings ..	5·6	..	..	..	..	..	..
14	*Cassia tora*	..	..	..	..	2·4	..	..
15	*Cedrela toona* seedlings ..	..	..	..	..	..	10·0	23·3
16	*Caryopteris wallichiana* ..	..	..	..	..	..	..	..
17	*Chloris barbata*	..	..	..	..	..	..	..
18	*Cissampelos pareira* ..	..	..	..	..	..	1·4	1·3
19	*Crotolaria siricea* ..	..	..	..	..	..	1·4	..
20	*Cynodon dactylon* ..	..	..	..	..	..	..	0·5
21	*Cynoglossum lanceolatum* ..	..	..	..	..	..	..	..
22	*Dalbergia sissoo* seedlings ..	..	..	2·0	2·4	4·8	2·1	2·2
23	*Desmodium triflorum* ..	..	..	1·0	1·2	..	9·3	3·1
24	*Dioscorea* sp.	..	..	..	..	..	..	0·5
25	*Dioscorea bulbifera* ..	..	..	..	..	..	..	..
26	*Erigeron linifolius* ..	3·3	..	..	..	1·2	..	..
27	*Eugenia jambolana* seedlings	..	..	..	..	1·2	..	..
28	*Euphorbia hirta* ..	3·2	1·6	..	..	..	0·7	0·4
29	*Hydrocotyle asiatica* ..	..	..	..	..	..	..	..
30	*Imperata cylindrica* ..	8·0	24·6	58·8	72·3	74·7	44·3	25·1
31	*Ipomoea hispida*	1·6	..	..	..	..	..	..
32	*Justicia simplex* ..	..	..	..	..	..	2·9	1·8
33	*Litsea polyantha*	..	..	..	..	..	..	..
34	*Mallotus philippinensis* seedlings	..	..	..	..	..	..	..
35	*Murraya koenigii* seedlings ..	..	..	..	..	..	2·1	0·5
36	*Nepata ruderalis* ..	..	..	..	..	..	..	0·5
37	*Oplismenus compositus* ..	..	..	..	..	..	..	..
38	*Oxalis corniculata* ..	..	..	..	..	..	..	4·0
39	*Paspalum* sp.	..	..	2·0	..	..	..	..
40	*Phyllanthus urinaria* ..	..	..	..	..	..	1·4	0·9
41	*Rottboellia compressa* ..	2·4	0·8	6·8	6·8	1·2	6·5	9·4
42	*Rubia cordifolia* ..	..	..	..	..	..	..	..
43	*Rubus lasiocarpus* seedlings ..	..	..	..	..	..	..	..
44	*Rubus* sp. seedlings ..	..	..	..	..	..	..	..
45	*Saussuria candicans* ..	..	..	..	..	..	..	..
46	*Sapium sebiferum* seedlings ..	..	..	..	..	..	..	..
47	*Sesbania* sp. seedlings ..	..	..	..	..	..	..	..
48	*Setaria glauca*	..	..	..	..	..	..	..
49	*Sida acuta*	..	..	..	..	3·6	..	..
50	*Sida cordifolia*	..	..	..	..	2·4	..	..
51	*Solanum nigrum*	..	..	..	..	..	..	..
52	*Urena lobata*	2·4	..	..	..	..	..	0·5

of species in a quadrat of Shorea robusta laid in compartment 20

24–9–38	28–9–39	10–10–40	1941	1942	25–9–43	29–9–44	29–10–45	15–10–46	1947	1948
..	..	4·1	6·1	5·0	6·4	..	..	..	..	3·1
23·2	26·6	31·0	39·8	2·5	15·5	10·3	1·2	3·0	41·7	44·8
0·4	..	..	..	..	..	..	..	..	..	..
0·4	0·5	0·5	1·0	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
..	1·5	..	..	..	..	..	..	..	..	..
8·2	9·4	7·6	3·1	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
1·7	..	0·5	..	..	0·9	..	..	..	..	..
0·4	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	0·9	1·0
0·4	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	0·9	..	..	..	2·8	1·0
8·2	11·8	14·2	22·4	37·5	..	22·2	34·1	26·9	9·3	10·4
0·9	..	..	..	1·2	0·9	0·8	1·2	1·4	..	..
1·7	..	1·0	1·0	..	..	..	..	..	..	..
0·9	1·0	2·0	..	..	2·7	0·8	3·5	..	0·9	..
..	..	..	..	..	..	..	..	..	..	..
..	..	2·0	3·1	..	2·7	2·4	..	..	..	..
0·9	..	..	..	..	..	..	..	..	..	..
1·3	1·0	1·0	3·1	2·5	..	..	..	..	..	..
1·3	..	..	..	..	..	..	..	..	..	..
0·9	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	25·4	18·3	..	..	3·7	..
..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	1·2	3·0	0·9	1·0
..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	1·2	..	..	..	..	..	..
27·4	29·6	19·3	4·1	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
3·0	7·4	4·1	..	..	..	..	..	..	..	..
..	..	0·5	..	1·2	1·8	1·6	2·3	3·0	1·9	2·1
0·4	..	..	1·0	1·2	0·9	1·6	1·2	3·0	0·9	1·0
0·9	1·0	3·5	7·1	11·3	7·3	6·3	8·2	6·0	4·6	6·3
2·1	3·0	1·5	..	..	..	..	..	..	..	..
..	1·0	1·0	6·1	18·8	26·4	31·0	45·9	50·4	30·6	28·1
7·3	2·0	1·0	..	2·5	0·9	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
4·3	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	7·5	0·9	3·2	..	3·0	..	..
..	..	1·5	2·0	3·8	2·7	1·6	1·2	..	0·9	..
..	0·5	..	..	..	..	..	..	..	..	..
0·4	2·4	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	0·9	1·0
..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	3·8	..	..	..	..	..	..
2·1	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
..	..	1·5	..	..	3·6	..	..	..	..	..
..	2·0	1·0	..	..	..	..	..	..	..	..

TABLE 11.—*Frequencies of different species as percentage of the total number*

Serial No.	Species	22–9–32	14–9–33	29–9–34	18–9–35	17–9–36	17–9–37	24–9–38
1	*Achyranthes aspera*	..	..	..	..	..	..	..
2	*Ageratum conyzoides*	33·8	55·2	63·2	34·2	25·5	38·5	43·3
3	*Apluda aristata*	..	..	..	0·9	2·5	2·4	..
4	*Artemisia vulgaris*	..	..	..	..	0·6	..	..
5	*Bidens pilosa*	..	..	..	0·9	0·6	5·4	..
6	*Broussonetia papyrifera* seedlings	..	..	..	..	..	..	..
7	*Cassia tora*	..	..	..	..	..	..	..
8	*Cedrela toona* seedlings	..	..	..	1·7	5·1	1·2	..
9	*Cissampelos pariera*	..	..	..	..	0·6	..	2·6
10	*Clerodendron infortunatum* seedlings	..	..	..	1·7	1·3	3·0	9·9
11	*Cynodon dactylon*	28·2	6·9	1·1	20·5	19·1	22·9	..
12	*Cyperus rotundus*	..	..	..	1·7	3·2	1·2	..
13	*Dalbergia sissoo* seedlings	8·4	5·7	3·4	4·3	3·2	1·8	3·3
14	*Desmodium triflorum* seedlings	..	..	..	..	0·6	..	..
15	*Dichanthium annulatum*	21·1	32·2	9·2	5·1	..	..	..
16	*Dicliptera roxburghiana*	..	..	..	..	..	..	..
17	*Dioscorea bulbifera*	..	..	..	..	..	..	..
18	*Eugenia jambolana* seedlings	..	..	..	0·8	0·9	..	..
19	*Fragaria* sp.	..	..	..	..	0·9	..	..
20	*Imperata cylindrica*	..	..	9·2	18·9	21·0	3·0	1·3
21	*Jasminum* sp. seedlings	..	..	..	..	..	..	0·7
22	*Justicia simplex*	..	..	..	..	5·7	6·8	8·5
23	*Kydia calycina* seedlings	..	..	..	..	..	..	..
24	*Litsea polyantha* seedlings	..	..	..	..	1·3	0·6	0·7
25	*Malvastrum tilifolium*	..	..	..	..	..	..	..
26	*Murraya koenigii* seedlings	..	..	..	..	..	1·8	2·0
27	*Oplismenus compositus*	..	..	..	..	..	..	..
28	*Oxalis corniculata*	..	..	..	..	1·9	4·2	1·3
29	*Phyllanthus urinaria*	..	..	..	..	1·3	..	1·3
30	*Rubia cordifolia*	..	..	..	..	..	1·8	..
31	*Rubus* sp. seedlings	..	..	..	..	..	..	0·7
32	*Sesbania* sp. seedlings	..	..	..	..	..	0·6	..
33	*Setaria glauca*	..	..	..	3·4	..	..	..
34	*Sida acuta*	..	..	..	..	..	3·0	..
35	*Sida cordifolia*	..	..	13·8	6·0	4·5	2·4	0·7
36	*Sida rhombifolia*	8·4	..	..	..	0·6	..	..
37	*Sida* sp.	..	..	..	..	..	..	..

of species in a quadrat of Shorea robusta laid out in compartment 18

25–9–39	10–10–40	1941	1942	25–9–43	21–10–44	25–10–45	15–10–46	1947	1948
..	0·7	1·4	..	3·6	2·1	1·6	..	..	1·2
42·6	38·6	5·5	4·6	1·8	2·1	0·8	..	42·6	35·4
..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	1·2
..	..	..	..	24·8	19·2	17·6	8·2	..	3·1
..	..	..	..	..	..	..	1·6	0·9	..
1·4	2·1	5·5	3·1	1·8	2·1	2·5	6·6	4·3	2·5
..	..	..	..	0·9	..	..	..	..	..
20·3	27·1	50·7	53·8	36·7	32·6	32·8	55·7	22·6	13·7
10·2	8·6	10·9	7·7	2·8	3·5	1·7	..	..	..
..	..	..	..	..	..	..	..	2·6	0·6
3·4	3·6	2·7	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..
..	1·4	..	..	..	..	..	..	0·9	1·2
..	..	..	..	0·9	..	0·8	..	0·9	..
0·7	1·4	1·4	1·5	0·9	0·7	0·8	3·3	0·9	1·2
..	..	..	..	..	..	..	..	..	..
1·4	..	..	..	..	..	..	..	..	..
..	1·4	..	1·5	0·9	..	1·7	1·6	0·9	..
0·7	0·7	..	..	..	..	..	..	..	0·6
..	..	..	..	..	..	..	..	..	0·6
0·7	1·4	4·1	4·6	0·9	1·4	1·7	8·2	0·9	1·9
..	..	..	..	..	..	..	..	..	..
2·8	5·0	9·6	12·3	8·3	6·4	14·3	11·5	3·5	3·1
..	..	..	3·1	15·7	28·5	24·4	1·6	14·8	31·7
0·7	..	..	1·5	..	..	..	..	1·7	..
..	..	..	..	..	..	..	..	..	..
0·7	1·4	..	..	..	..	0·8	..	..	..
0·7	0·7	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..
..	..	..	1·5	..	..	..	..	..	..
..	..	..	..	..	1·4	..	..	0·9	1·2
..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..
12·9	5·7	..	4·6	..	..	..	..	..	..

TABLE 12.—*Frequencies of different species as percentage of the total number*

Serial No.	Species	19–9–32	15–9–33	Sept. 34	20–9–35	18–9–36	19–9–37	29–9–38
1	*Achyranthes aspera* ..	..	..	..	..	..	..	..
2	*Ageratum conyzoides* ..	19·4	48·2	13·3	10·0	16·5	23·3	24·4
3	*Ajuga bracteosa*	..	..	..	0·7	11·4	2·4	..
4	*Alysicarpus rugosus* ..	..	..	..	..	..	0·6	..
5	*Artemisia vulgaris* ..	20·9	1·2	1·3	3·5	1·8	1·5	2·3
6	*Asclepias* sp.	..	..	..	..	..	..	..
7	*Bidens pilosa*	..	..	..	..	0·4	..	..
8	*Blainvillea rhomboidea* ..	..	..	..	..	..	0·3	..
9	*Bothriochloa pertusa* ..	..	..	..	..	0·4	0·9	..
10	*Broussonetia papyrifera* seedlings ..	..	..	..	..	..	..	..
11	*Carissa opaca* seedlings ..	..	..	..	..	..	..	..
12	*Cassia mimosoides* seedlings ..	..	..	..	..	..	..	..
13	*Cassia tora*	13·0	..	..	8·5	1·1	..	..
14	*Cedrela toona* seedlings ..	..	..	..	..	5·7	18·4	19·5
15	*Celastrus paniculata* seedlings ..	..	..	..	..	..	..	..
16	*Celtis tetranda* seedlings ..	..	..	..	..	..	..	..
17	*Cissampelos pareira* ..	..	..	..	..	0·4	..	1·1
18	*Cinnamomum camphora* seedlings ..	..	..	..	..	..	..	..
19	*Chloris barbata*	..	..	..	..	..	..	2·3
20	*Clerodendron infortunatum* seedlings	..	..	..	..	..	..	..
21	*Cryptolepis buchanani* seedlings ..	..	..	..	..	..	..	..
22	*Cynoden dactylon* ..	..	..	..	2·1	0·7	0·3	..
23	*Cynoglossum lanceolatum* ..	..	..	..	..	..	..	..
24	*Cyperus rotundus* ..	..	..	..	1·4	..	0·3	..
25	*Dalbergia sissoo* seedlings ..	..	..	..	0·7	0·7	0·6	..
26	*Desmodium polycarpum* ..	..	..	..	..	0·7	..	..
27	*Desmodium* sp.	..	..	..	..	..	..	..
28	*Desmodium triflorum* ..	..	..	..	1·4	3·9	4·8	..
29	*Dichanthium annulatum* ..	15·8	..	..	..	..	0·6	..
30	*Dicliptera roxburghiana* ..	..	..	..	..	..	..	..
31	*Dioscorea bulbifera* ..	..	..	..	..	..	..	..
32	*Eugenia jambolana* seedlings ..	..	..	..	..	0·4	..	..
33	*Euphorbia geniculata* ..	6·5	..	..	2·1	0·4	..	..
34	*Euphorbia hirta*	..	..	..	..	0·7	..	..
35	*Ficus palmata* seedlings ..	..	..	..	..	..	1·2	1·9
36	*Grewia tiliaefolia* seedlings ..	..	..	..	..	..	..	..
37	*Hemarthria compressa* ..	..	..	..	..	..	..	0·8
38	*Hydrocotyle asiatica* ..	..	..	..	..	..	..	..
39	*Imperata arundinacea* ..	19·4	50·6	85·3	39·0	16·5	10·0	5·7
40	*Imperata cylindrica* ..	..	..	..	..	..	..	..
41	*Justica simplex*	..	..	..	..	4·5	15·1	6·9
42	*Litsea polyantha* seedlings ..	..	..	..	..	..	..	0·4
43	*Mallotus philippinensis* seedlings ..	..	..	..	..	..	..	..
44	*Melia azedarach* seedlings ..	..	..	..	2·1	1·1	0·3	..
45	*Morus alba* seedlings ..	..	..	..	..	..	..	1·1
46	*Murraya koenigii* seedlings ..	..	..	..	..	..	0·3	0·4
47	*Nepeta ruderalis*	..	..	..	..	7·5	0·6	..
48	*Nephelium litchi* seedlings ..	..	..	..	..	..	0·6	1·9
49	*Oplismenus compositus* ..	..	..	..	..	..	..	3·4
50	*Oxalis corniculata* ..	..	..	..	..	..	..	6·1
51	*Phyllanthus urinaria* ..	..	..	..	7·1	1·22	1·5	2·3
52	*Psidium guava* seedlings ..	..	..	..	..	0·7	1·8	..
53	*Rottboellia compressa* ..	..	..	..	..	0·7	1·2	..
54	*Rubia cordifolia*	..	..	..	..	..	..	1·1
55	*Rungia repens*	..	..	..	..	..	..	11·1
56	*Saccharum spontaneum* ..	..	..	..	..	..	..	..
57	*Sapium sebiferum* seedlings ..	..	..	..	..	..	..	..
58	*Setaria glauca*	5·0	..	..	4·2	1·4	..	..
59	*Sida acuta*	..	..	..	..	..	..	..
60	*Sorghum halepense* ..	..	..	..	0·7	..	..	0·8
61	*Sida cordifolia*	..	..	..	..	7·5	1·2	..
62	*Sida rhombifolia* ..	..	..	..	15·6	1·4	9·7	..
63	*Urena lobata*	..	..	..	..	..	..	..
64	*Vernonia cinerea* ..	..	..	..	..	..	0·6	..
65	*Woodfordia floribunda* seedlings ..	..	..	..	..	..	..	..
66	*Zizyphus jujuba* seedlings ..	..	..	..	..	0 4	..	..

of species in a quadrat of Pinus longifolia, laid in compartment 41

25–9–39	10–10–40	1941	1942	24–3–43	20–9–44	25–10–45	16–10–46	25–10–47	1948
..	0·4	..	0·3	0·4	5·5	10·2	8·0	8·3	..
21·2	23·3	23·0	37·4	8·1	27·0	25·6	32·8	25·8	6·8
..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..
2·0	1·8	1·1	0·3	0·4	0·3	0·3	0·2	0·4	0·3
0·3	..	..	..	..	..	..	..	..	..
..	..	..	..	0·9	..	..	..	..	0·3
..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..
..	0·4	..	..	..	..	..	..	..	..
..	..	..	0·3	0·4	0·3	0·6	0·2	0·4	0·3
..	..	..	..	..	..	..	..	..	18·7
0·3	0·7	..	..	0·4	..	0·6	0·2	0·4	..
20·3	13·1	21·8	16·2	16·7	14·0	14·1	9·2	11·7	7·5
..	..	..	..	..	..	..	1·0	..	..
..	0·4	0·5	0·3	0·9	0·3	0·6	0·5	0·4	..
..	..	..	..	2·1	0·6	1·2	..	0·4	0·3
..	..	1·1	0·3	..	..	..	0·7	..	..
1·6	1·5	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	6·8	0·3
..	..	..	0·3	0·4	0·6	0·6	0·5	0·4	0·3
..	0·7	0·5	1·1	0·4	..	0·9	0·5	0·4	..
..	..	..	..	..	..	..	..	..	..
..	..	..	..	1·3	0·3	..	..	..	0·3
0·3	1·1	..	1·1	2·6	1·6	..	..	..	0·7
..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	Data not clear	8·8
..	..	..	..	..	..	..	2·2	..	..
..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	2·7	Data not clear	12·6
..	..	..	..	9·0	6·8	0·9	1·0	..	..
0·3	..	..	..	..	..	..	..	..	..
..	..	..	..	..	1·0	0·3	..	..	..
..	..	..	..	..	..	..	..	..	..
2·3	2·4	6·1	2·5	4·7	3·0	3·6	2·0	2·1	2·4
..	..	..	..	..	..	..	..	0·4	..
0·3	0·4	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	0·2	..	..
4·6	5·8	10·0	..	..	..	..	..	18·3	13·6
..	..	..	6·0	10·3	6·1	4·5	9·0	..	..
8·5	3·6	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	0·3
..	0·4	..	..	0·4	..	..	0·5	..	..
..	..	..	..	..	..	..	..	..	..
1·3	1·1	1·7	1·7	1·3	1·3	1·8	0·5	2·1	1·0
0·6	0·4	0·5	1·3	0·4	0·3	0·3	..	0·4	0·3
..	..	..	..	..	..	..	..	..	..
1·3	1·5	1·1	..	..	..	..	..	..	..
6·5	15·3	31·3	26·5	16·7	21·4	20·0	13·8	13·5	3·7
1·0	..	..	..	..	..	..	..	..	2·0
2·0	..	..	..	..	..	..	..	..	..
1·6	2·2	1·1	0·7	0·4	1·3	0·9	0·5	0·4	2·0
..	..	..	..	..	..	..	..	..	..
2·3	2·5	..	1·1	3·0	1·3	1·5	1·2	0·4	0·3
14·4	15·3	..	..	..	..	..	..	..	..
..	..	..	0·3	0·4	..	..	..	..	..
..	..	..	..	..	0·3	..	..	..	..
..	..	..	..	..	..	..	..	..	..
1·0	2·2	..	..	..	..	..	3·4	10·0	11·2
1·3	..	..	..	..	..	..	..	0·4	..
..	..	..	..	..	..	..	..	..	..
..	..	..	..	11·6	4·9	7·2	..	..	..
..	..	..	2·8	3·0	1·6	4·2	8·2	..	2
..	..	..	..	..	..	..	..	..	..
..	..	..	..	0·4	..	..	..	..	0
..	..	..	..	..	..	..	..	..	..

TABLE 13.—*Frequencies of different species as percentage of the total number*

Serial No.	Species	23–5–31	14–7–31	23–9–31	28–9–32	15–9–33	Sept. 34	20–9–35	17–9–36
1	*Acalypha indica*	..	..	..	..	..	..	2·0	14·2
2	*Achyranthes aspera*	..	..	..	..	1·2	..	1·0	0·7
3	*Ageratum conyzoides*	..	21·5	33·0	52·1	62·2	95·0	42·8	12·0
4	*Ajuga bracteosa*	0·7	..	..	..	..	..	1·0	..
5	*Albizzia procera* seedlings	0·7	..	0·9	1·4	..	..	1·0	0·4
6	*Artemisia vulgaris*	..	..	..	..	..	..	5·5	3·7
7	*Bidens pilosa*	..	..	..	..	..	..	..	..
8	*Broussonetia papyrifera* seedlings	..	..	..	..	..	..	..	3·0
9	*Cedrela toona* seedlings	..	..	..	..	..	..	..	9·7
10	*Celastrus paniculata* seedlings	..	..	..	..	..	..	..	..
11	*Carissa opaca*	..	..	..	..	..	..	..	..
12	*Cassia tora*	..	..	..	..	..	..	..	..
13	*Clerodendron infortunatun* seedlings	..	..	..	..	..	..	..	..
14	*Cissampelos pareira*	..	..	..	..	..	..	..	..
15	*Corchorus olitorius*	..	..	..	..	..	..	1·5	1·9
16	*Cryptolepis buchanani* seedlings	..	..	..	..	..	..	..	..
17	*Cynodon dactylon*	8·0	..	..	5·6	..	..	8·0	7·5
18	*Cyperuss rotundus*	..	..	..	..	..	..	6·5	0·4
19	*Dalbergia sissoo* seedlings	1·4	1·1	1·8	4·2	2·4	..	1·0	0·7
20	*Dioscorea bulbifera*	..	..	..	..	..	..	..	..
21	*Desmodium* sp.	..	..	..	..	..	..	..	..
22	*Dichanthium annulatum*	15·1	18·5	6·2	..	..	..	..	0·7
23	*Erigeron linifolius*	14·4	6·2	4·5	..	..	..	..	..
24	*Eugenia jambolana* seedlings	..	..	..	..	..	..	1·0	0·7
25	*Euphorbia hirta*	..	5·4	7·0	..	..	..	..	..
26	*Hamiltonia suaveolens* seedlings	..	..	..	..	..	..	..	..
27	*Hibiszcus pungens* seedlings	..	..	0·9	..	..	..	2·0	1·9
28	*Hydrocotyle asiatica*	..	..	..	..	..	..	0·5	1·5
29	*Ipomaea hispida*	..	3·1	2·7	..	..	..	..	..
30	*Ipomaea hederacea*	..	..	..	..	..	..	..	..
31	*Justicea simplex*	..	..	..	..	..	..	2·5	8·6
32	*Litsea chinensis* seedlings	..	..	..	..	..	..	0·5	..
33	*Litsea polyantha* seedlings	..	..	..	..	..	..	..	0·4
34	*Mangifera indica* seedlings	..	..	..	..	1·2	..	0·5	0·4
35	*Melia azedarach* seedlings	..	..	..	..	..	..	1·0	..
36	*Murraya koenigii* seedlings	..	..	..	..	..	..	..	0·4
37	*Nepeta ruderalis*	..	..	..	..	..	..	..	1·1
38	*Oenothera rosea*	..	..	..	..	..	..	..	0·4
39	*Oplismenus compositus*	..	..	..	..	..	..	..	..
40	*Paspalum sanguinale*	..	..	..	..	..	..	..	..
41	*Phyllanthus urinaria*	..	..	..	..	..	..	1·5	11·6
42	*Rotboellia compressa*	10·0	11·5	4·5	30·0	26·8	14·9	7·5	17·4
43	*Rubia cordifolia*	..	..	..	..	..	..	..	..
44	*Sapium sebiferum* seedlings	..	..	..	..	..	..	..	..
45	*Sida rhombifolia*	10·0	7·7	13·4	..	..	..	..	0·4
46	*Scoparia dulcis*	..	8·5	10·7	..	..	..	..	..
47	*Sorghum halepense*	19·0	8·5	14·3	7·0	6·1	5·0	5·5	8·6
48	*Verbena officinalis*	20·9	..	..	...	..	..	..	0·7

of species in a quadrat of Pinus longifolia laid out in (unburnt) compartment 23

15-9-37	9-10-38	25-9-39	10-10-40	Oct. 41	1942	23-9-43	22-9-44	22-10-45	15-10-46	1947	11-11-48
..	..	3·2	1·4	...	..	..	..	..	...	..	..
1·8	1·7	1·3	..	..	..	..	..	..	..	..	..
36·1	51·7	39·0	40·4	38·0	40·5	23·0	20·5	9·8	9·8	3·5	9·1
1·2	..	..	..	..	..	..	..	..	..	..	..
..	0·9	0·6	0·7	0·6	0·4	0·5	0·4	0·3	..	0·3	0·3
1·2	..	..	..	0·6	0·4	..	0·4	..	..	..	..
10·2	..	..	..	..	..	..	..	..	..	..	0·3
..	14·7	24·0	23·5	24·0	12·1	17·3	14·5	9·2	8·9	6·2	6·0
8·4	20·7	16·9	15·1	12·0	6·5	8·7	8·4	6·0	5·8	6·2	2·8
..	..	..	..	0·6	0·9	..	0·4	1·1	0·3	0·3	0·3
..	..	..	..	..	..	0·5	2·4	5·4	3·4	..	6·3
..	..	..	..	..	..	0·5	0·4	0·5	0·3	0·3	0·3
..	..	..	..	..	0·9	4·6	8·2	0·3	9·2	12·5	15·7
...	..	..	..	..	..	..	..	..	..	0·5	..
..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	0·6	0·4	0·5	..	0·3	0·3	..	..
2·4	1·7	0·6	0·7	..	..	..	..	..	..	..	..
3·0	..	0·6	0·7	..	..	1·5	..	..	..	..	..
1·8	1·7	1·3	1·4	1·3	0·9	1·5	1·2	0·8	0·9	..	0·9
..	..	..	..	..	..	1·0	1·6	0·3	0·3	..	..
..	..	..	..	..	..	..	..	..	..	1·1	..
..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..
1·2	0·9	1·3	1·4	0·6	0·9	1·0	0·8	0·8	0·8	0·8	0·6
..	..	..	..	..	0·4	..	..	..	..	..	..
..	..	..	..	0·6	..	0·5	0·4	0·3	0·3	0·5	0·3
6·6	0·9	1·3	1·4	..	..	1·0	0·8	0·8	2·1	5·4	2·5
1·8	1·7	3·2	3·4	6·3	4·0	5·1	5·2	5·7	3·1	..	2·2
..	..	..	..	..	..	..	..	..	..	..	..
0·6	..	..	..	..	..	..	..	..	..	..	..
1·2	..	1·3	..	..	..	..	..	..	0·6	..	..
0·6	0·9	0·6	..	0·6	0·4	1·5	4·0	5·4	5·5	3·5	5·7
..	..	..	0·7	0·6	0·9	0·5	0·8	0·5	0·3	..	..
..	0·9	0·6	0·7	..	0·4	0·5	0·4	0·3	0·3	0·3	0·3
..	..	..	..	..	..	..	..	..	..	..	..
0·6	0·9	0·6	1·4	1·3	1·3	2·0	3·2	1·6	3·1	..	3·1
..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..
..	..	1·9	2·8	12·0	28·4	26·0	28·1	44·0	43·3	53·0	40·0
0·6	..	..	..	..	..	..	..	..	..	..	..
..	0·9	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	0·5	0·4	1·4	0·3	..	..
..	..	..	..	..	0·4	1·0	2·4	1·4	1·2	2·7	2·2
..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..
1·8	..	1·3	3·4	..	..	..	..	..	..	..	..
...	..	..	..	..	..	..	..	..	..	..	..

TABLE 14.—*Frequencies of different species as the percentage of the total number*

Serial No.	Species	4–3–36	17–9–36	19–9–37	9–10–38	25–9–39
1	*Acalypha indica*	..	6·8	18·6	22·7	20·3
2	*Achyranthes aspera*	..	..	..	..	..
3	*Ageratum conyzoides*	53·3	6·8	19 1	12·1	14·6
4	*Ajuga bracteosa*	..	7·7	..	..	..
5	*Albizzia procera* seedlings	0·4	0·4	0·4	..	0·3
6	*Apluda aristata*	2·3	0·9	4·2	..	..
7	*Artemisia vulgaris*	0·8	0·9	..	..	0·3
8	*Bidens pilosa*	..	..	..	..	..
9	*Broussonetia papyrifera* seedlings	..	..	..	1·5	1·7
10	*Carissa opaca* seedlings	0·8	..	..	..	..
11	*Cassia tora*	..	0·9	0·4	1·5	1·0
12	*Cassia mimosoides* seedlings	..	..	..	..	..
13	*Cedrela toona* seedlings	3·4	26·1	11·0	6·4	6·1
14	*Corchorus olitorins*	..	6·8	..	..	..
15	*Cissampelos pareira*	0·4	0·4	0·4	..	0·3
16	*Clerodendron infortunatum* seedlings	..	..	..	..	..
17	*Cynodon dactylon*	9·8	1·4	2·1	1·9	2·0
18	*Cyeprus rotundus*	0·4	..	1·7	1·5	0·3
19	*Dalbergia sissoo* seedlings	0·8	1·4	0·8	0·4	0·3
20	*Desmodium sp.*	..	..	..	..	..
21	*Desmodium triflorum*	..	..	..	..	..
22	*Dicliptera roxburghiana*	..	..	..	..	..
23	*Dioscorea bulbifera*	..	..	..	0·4	..
24	*Eugenia jambolana* seedlings	..	..	..	..	..
25	*Euphorbia hirta*	..	0·4	..	..	..
26	*Ficus palmata* seedlings	..	..	..	..	..
27	*Hemarthria compressa*	..	..	..	8·0	4·7
28	*Hydrocotyle asiatica*	..	0·4	0·8	..	..
29	*Imperata arundinacea*	0·4	0·4	0·4	1·5	6·1
30	*Imperata cylindrica*	..	..	..	..	..
31	*Ipomaea hederacea*	..	0·4	..	..	..
32	*Justicia simplex*	..	1·8	..	..	5·4
33	*Kydia calycina* seedlings	..	..	..	..	..
34	*Litsea polyantha* seedlings	..	..	..	..	..
35	*Melilotus parviflora*	..	..	..	..	..
36	*Michelia champaca* seedlings	..	..	..	..	..
37	*Morus alba* seedlings	..	..	..	..	1·4
38	*Murraya koenigii* seedlings	..	0·4	..	0·4	..
39	*Nephelium litchi* seedlings	..	..	0·4	..	..
40	*Nepeta ruderalis*	4·8	7·2	..	..	2·7
41	*Oenothara rosea*	2·6	..	..	..	..
42	*Olpismenus compositus*	..	..	..	3·0	10·5
43	*Oxalis carniculata*	0·8	..	0·4	..	..
44	*Phyllanthus urinarea*	..	6·8	2·1	14·0	..
45	*Paspalidium flavidum*	..	..	..	..	..
46	*Paspalum scorbiculatum*	..	..	..	..	..
47	*Plectranthus strictus*	..	..	..	..	..
48	*Physalis minima*	..	3·6	..	1·5	..
49	*Rungia parviflora*	..	..	..	..	..
50	*Rottboellia compressa*	..	3·6	7·6	..	..
51	*Rubia cordifolia*	..	..	..	..	..
52	*Rubus ellipticus* seedlings	9·7	..	..	..	..
53	*Rubus lasiocarpus* seedlings	..	..	..	..	..
54	*Sapium sebiferum* seedlings	..	0·4	..	..	..
55	*Sida acuta*	..	..	..	..	..
56	*Sida rhombifolia*	..	0·9	5·5	..	..
57	*Setaria glauca*	..	..	..	0·4	..
58	*Sorghum halepense*	4·5	6·8	13·1	13·3	11·5
59	*Solanum nigrum*	..	..	..	..	..
60	*Tinospara cordifolia* seedlings	..	..	..	..	..
61	*Urena lobata*	0·4	0·4	1·3	1·1	4·1
62	*Zizyphus jujuba* seedlings	4·8	1·4	4·2	6·4	6·1

of species in a quadrat of Pinus longifolia laid out (burnt part) in compartment 23

10-10-40	1941	1942	24-9-43	18-9-44	19-10-45	15-10-46	25-10-47	1948
18·5	0·6	..	17·3	6·6	1·3	..	..	..
..	..	..	..	..	..	0·7	..	..
12·1	9·8	26·0	1·3	0·6	1·3	4·3	..	1·4
..	..	..	..	..	..	..	0·4	3·2
..	..	1 0	0·4	0·3	1·0	..	1·2	0·4
..	..	..	..	..	..	..	..	..
0·6	0·6	4·0	1·3	0·6	..	..	..	..
..	..	..	..	..	..	..	..	..
2·1	2·3	..	1·3	1·4	0·7	2·2	0·8	0·4
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	5·4
5·5	10·3	..	4·6	5·2	5·3	10·1	7·1	5·0
..	..	..	..	..	..	..	..	..
0·9	..	..	2·1	..	..	1·5	0·8	0·4
..	..	..	..	..	..	..	..	22·2
1·2	..	..	16·0	21·4	0·7	..	0·8	1·4
0·3	..	..	0·4	..	..	..	..	0·4
0·3	..	1·0	0·4	0·3	0·3	..	0·4	0·4
..	..	..	..	..	..	..	0·4	0·4
..	..	..	..	..	..	0·7	..	..
..	..	..	..	..	..	..	13·4	12·2
..	..	..	4·6	7·2	1·0	0·7	..	..
..	..	..	..	..	..	0·7	0·4	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
10·0	..	..	..	..	..	..	..	..
..	..	2·0	0·4	0·6	..	..	..	..
7·9	14·9	..	..	..	..	..	..	21·9
..	..	10·0	7·2	25·4	25·8	45·7	51·8	..
..	..	..	..	..	..	..	..	..
7·3	..	..	..	..	..	..	..	..
..	..	..	..	..	..	0·7	0·4	0·4
..	..	3·0	..	..	..	..	..	0·7
0·9	..	..	..	..	15·6	..	..	..
..	..	1·0	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
0·3	0·6	1·0	0·4	0·3	0·7	..	0·4	0·4
..	..	..	..	..	..	..	..	..
3·0	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
12·7	14·4	4·0	2·5	3·2	..	..	..	5·4
..	..	..	..	..	..	..	..	..
..	..	..	9·3	0·6	0·3	..	..	..
..	..	..	..	..	2·6	..	..	..
..	..	..	..	..	..	..	..	2·1
..	..	..	..	..	..	..	0·8	..
..	..	..	..	..	..	..	..	..
..	..	..	0·4	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	2·0	..	1·2	..	..	..	0·4
..	..	..	0·8	1·2	0·7	..	..	..
..	..	..	..	..	..	0·7	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	1·2	1·0	0·7	..	0·7
..	..	..	1·3	..	..	..	..	..
..	..	..	..	..	..	..	..	..
10·3	17·8	26·0	16·5	8·4	23·5	6·5	..	2·5
0·3	..	..	..	..	..	..	..	..
0·3	..	..	..	..	..	..	..	..
1·2	..	1·0	1·3	..	..	0·7	4·7	6·0
4·2	7·5	14·0	6·3	5·8	5·6	..	4·7	6·0

SUMMARY

Small ground flora quadrats, one each, were laid in plantations of *Gmelina arborea*, *Tectona grandis*, *Shorea robusta*, *Pinus longifolia* and *Dalbergia latifolia* at the New Forest and frequencies of almost all the ground vegetation have been recorded over a period of 1928–1949 (in some cases). These data have been examined and an effort has been made to correlate the frequencies of various species with the growth and development of tree species. Although, some correlation seems evident the data, have unfortunately, not been collected clearly enough to bring out exact correlations. These data serve as a guide to lay properly further plots in the area.

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REMINISCENCES OF A FOREST OFFICER – HIS FIRST PANTHER

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Forest settlement work gives one many opportunities, of making many intimate contacts with rural life. The village *shikari* is an important person and it is well to get to know him intimately and be in his good books if you are at all interested in big game shooting. By Big game, in scrub jungle, I mean the panther, pig, spotted deer, *chinkara*, *sambar*, jungle sheep and an occasional tiger. The habits of these denizens of the forest are well known to the *shikari* and every *sahib*, be he an official or a non-official, who comes for *shikar* in the village has necessarily to seek his help to get beaters to drive game and put up a *machan* to tackle the panther. The *patel* or the village munsiff and the village *karnam* have to seek his help for their periodic supply of venison and pork and have, therefore, to be in his good books. The *shikari* knows every inch of the forests, particularly those localities where salt licks and water holes exist, for it is in these localities the local villagers hunt for their bag of illicit game. Evidence of this is easily obtained on a casual inspection of a forest when cage-like structures commanding a view of a water hole will be discovered. The forest guard, who usually is blamed for lack of vigilence is, poor man, helpless in the matter for he dare not book the offender lest he make himself unpopular with the villagers who can make his life miserable for exposing their crimes. Besides, he often has a share in the game and it will not be profitable to expose his confederates. How, then, is he to please both the masters ? Not seldom do cases come to light of murders of overstrict forest subordinates committed to avenge the exposure of culprits involved in forest offences.

Such a case came to light in KUNDU KOTA village of Salem district during my time. The V.M., as the *patel* is commonly called, in Tamil district of this place, was a wealthy influential person who, for some reason, was hostile to the forest subordinates. He was known to possess several herds of cattle including goats, and it was his pride that he had never taken out permits for grazing his cattle in reserve forests. The forest subordinates were afraid to report against him. It so happened that a young and active recruit was newly posted to this beat, and he soon got scent of the state of affairs in the village and promptly reported the matter to the officer above him. Information was received that an organized hunt has been arranged on a certain holiday and all the available guns and beaters had been invited for the beat. This information reached us when a conference of forest officers was being held at 'D' the Range Headquarters and we decided to take action immediately. We sent for the neighbouring beat guards and foresters, got two cars ready to take us all to the forest, 15 miles away, and started off at 5 a.m. the next morning on the track of the hunting party. On reaching the village, we got scent that the party has already moved on and were going over the forest in a large party with dogs and guns, and beaters shouting at the top of their voice to drive the game. We arrived on the scene just as a doe was being skinned before being cut up for meat and at sight of us, the *shikaris* fled leaving the partly carved doe behind. The young recruit, however, gave chase and succeeded in arresting one of the hunters armed with a muzzle loader gun. The rest of the party escaped and eluded our pursuit.

The accused was taken to the police station and a forest case was made out for illicit hunting and possession of unlicensed gun. The case, which was keenly contested by the defence, finally ended in conviction and the accused was fined Rs. 50. Though there was a lull in organized hunt in the Reserved Forest, the tension between the forest subordinates and the villagers increased and culminated in an assault on the Forest Guard who had reported

the hunting case. He was way-laid on a lonely road one night and beaten up so badly that he was given up for dead. Fortunately he was discovered by a forest watchman, put in a cart and taken to the nearest hospital, where he was treated for multiple injuries and finally discharged cured after a month. The forest subordinates in the village thereafter feared badly at the hands of the villagers. They were denied common amenities like houses to live in and supplies of milk and grain and boycotted at all social functions.

I have narrated this incident to show how easy it is to make or mar the good relations that must exist between the forest department and the rural inhabitants, especially in the case of forest subordinates who come constantly into intimate contact with the *ryots*. I have often found the villagers very helpful in exploring the jungle and acting as guides or as beaters in *shikar*. It is generally my practice to go out exploring the remotest jungle or hillock with only my dog for company and my ·22 rifle for an emergency. A flask of hot coffee in the haversack, a pair of powerful field glasses and a knife complete the equipment. So equipped you have an opportunity to gain an intimate knowledge of the forest in your charge as well the needs of the village folk in neighbouring villages – Not frequently the first sight you see is a party of village dames and damsels stealing firewood from the Reserved Forest. My bitch "Ranee" knows how to scare them. They flee at sight of the bitch and Ranee amused at their plight gives chase to scare them. We proceed further and climb up a knoll. On top of this is a huge rock and we scramble up its summit and pause and admire the scenery revealed to view. There, with a mantle of cloud all along her sides, stands "Karadi-guddai" the 3,000 feet high peak, with its top ablaze in the rosy hue of the rising sun. Down her precipitous sides are two streamlets coming down in white frothy water falls to the perennial pool at the foot of the hill. One may sit and admire the scene for hours but we have work ahead of us and must tear ourselves from this scene. So, after a sip of hot coffee from the flask and a puff at the cigarette, I reluctantly followed Ranee who has been nosing round and pricking up her ears as in anticipation of some excitement. We had not been afoot half a mile when we heard a gentle tap-tap which attracted Ranee's attention and off she went to investigate. I followed leisurely and soon came upon a scene which, if anything, was comical beyond description. Here was a young stalwart with a heavy bundle of bamboo on his head going round and round a clump of bamboos with Ranee close on his heels. He wailed piteously to me to call the dog off which I promptly did and assured him the dog will not hurt him if he stayed quite. On interrogating him he admitted his guilt and begged to be excused for cutting the young culms. There was nothing to be done but to march him to the nearest village 5 mile away and leave the bamboos in the charge of the V.M. We got going again and traversed some interesting forest of *Anogeissus* which, I noticed, had been recently burnt destroying the regeneration and the seeds on the ground. The fire had not been reported by the beat subordinates and I was engaged in noting its extant on my map and incidentally watching an elusive little wood pecker with my glasses when our friend the bamboo cutter thought it opportune to make a bid for freedom. Snatching his bill hook from the bundle he threw the load down and bolted. I gave chase, so did Ranee. We came up with him after a while and this time Ranee meant business and was about to attack him when I intervened and grabbed the knife from him lest he harm either of us with it. He showed no fight after this but picked up his bundle and followed us to where a party of forest subordinates were at work clearing the boundary line. One of the forest guards was sent off with the culprit for necessary action in regard to the offence.

It was while returning to camp that we met a party of villagers who were searching for a goat which they said had been killed and carried away by a panther. They showed us blood marks on the ground and sought permission to enter the forest where the blood traces indicated that the goat had been dragged. I readily granted permission and in fact joined in the search, with Ranee to assist us. It took well over half an hour to trace the carcass which

had been dragged into a bush well hidden from view. I told the villagers not to touch the carcass and said that I would sit up over the kill and avenge the slaughter of the goat.

It was a good 3-mile march to camp and it took me a couple of hours to get there and back. It was past 2 p.m. already and so there was no time to waste to prepare for the vigil to tackle the panther. I invariably take to camp a net hammock to serve as *machan* for an emergency like this. This was packed off along with the ·22 bore gun and electric torch to the forest. A few slices of bread and a flask of coffee in the *shikar* bag and I was ready to spend a night in the forest if need be. A hammock is, no doubt, not an ideal *machan* for a panther shoot but it has the advantage of being light and portable and easy to set up in the forest. All that is needed is a couple of 10 feet long hemp ropes at the ends of the hammock to fasten it on the trees. It can be manipulated with a single person and is fairly comfortable. The disadvantage is that a steady aim is difficult to get as the hammock swings with the slightest movement. Also, unlike the *machan* it can accommodate only one person. It took me barely 15 minutes with the assistance of a forest guard to set up the *machan* and climb into it. The guard was instructed to march off to a cattle farm half a mile away and there wait for me. He was on no account to come to me unless I whistled thrice or fired two shots in quick succession.

The *machan* stood about 12 feet high from the ground and though this was not a safe enough height to avoid the attack of a ferocious panther, I had no alternative tie up as trees were scarce and a good view of the kill was not procurable. When I had settled down on the hammock it was about 5-30 p.m. and there was yet an hour for sun set. It was a warm day and I commanded a good view of an open bush jungle with a pond containing some water on its fringe. While I reclined and waited I could see doves coming in to quench their thirst at the water's edge. A group of babblers were screeching while they picked up grubs from the leaves. A pair of *bulbuls* were whistling their familiar 'Be quick' while they preened each other and a drongo was making a diving attack on their head from a high perch. I had an opportunity to watch all these pranks unobserved; it was not more than half an hour I was thus engaged when I noticed a certain sense of alarm in all bird-life. Peering through my glasses I got a glimpse of an animal gliding stealthily through the bushes. I made sure this was my panther for a pair of crows was closed on its heels cawing the whole time as if to warn the other denizens of the forest of a preying enemy. I could not see Mr. sports for the forest cover was thick at this place but from the attention paid by the birds I made out that it was close to the kill. The tension of watching for a good view of the brute was too much for my nerves for my heart kept "thumping like a locomotive", the whole time I kept a watch for getting home a shot. The light was fast fading and I made out through my glasses what looked like the flanks and shoulders of the beast. The head and neck were not visible, being hidden behind a tree stump. Taking as steady an aim as my throbbing heart would permit, I fired at the spot where I thought the vital region of the heart would be. But alas! all I heard and saw was an angry growl from the beast which made a sudden crash through the jungle and disappeared from view.

Did I miss my shot? There was no conceivable excuse for it as the range was scarcely 15 yds.; and the light was tolerably good. Perhaps I had not hit the animal at a vital spot. Anyway there was nothing to be done but wait for the next day. So, after half an hour I whistled for the forests guard who shared my disappointment at the lack of luck, and we walked back to camp thoroughly dejected.

The next morning at the break of dawn the guard and I were back at the kill and on close scrutiny discovered traces of blood along the path which the panther has taken in its rush from the kill. Some distance ahead a pool of frothy blood was seen indicating that the

brute had been badly wounded and had rolled on the ground. It was unsafe to continue the search alone any further for a wounded panther is a serious menace to human life. So, I decided to call off the search and to drive a herd of cattle to locate the panther. For this purpose I sought the help of V.M. who happened to be the same man whose hunt we had frustrated previously. Bearing this grudge in mind, he not only refused us help but induced the villagers not to offer the services of their cattle for tracing the wounded panther.

Thus was lost an opportunity to win a trophy and my first encounter with a panther ended in bitter disappointment. A few days later the graziers brought me the claws of the dead panther which they discovered lying about near the partly eaten carcass of the brute.

SCIENCE NOTES

The statistical portion of Science Note No. I entitled "Preliminary note on the debudding trials on *Pinus logifolia* in New Forest, etc.", which was published on pp. 571–3 of the September, 1954 issue of this Journal, was prepared in the Statistical Branch of the Forest Research Institute, Dehra Dun. *Hon. Editor.*

I

Tests on the efficacy of Fernoxone in killing various forest trees

Fernoxone, a selective weedicide, contains 80 per cent of a sodium salt of 2, 4-dichlorophenoxyacetic acid (2, 4-D).

The toxicity of fernoxone to trees and consequently its usefulness in chemical thinning or cleaning of forest crops has been the subject of investigation in the Research Garden of the Forest Research Institute, Dehra Dun, since 1952. The available literature shows that various chemicals in different concentrations and solvents have been tried from time to time for killing unwanted trees. Among them are :—Sodium dichloracetate (½ lb. to a gallon of water) ; Sodium carbonate (2 lbs. to a gallon) ; Sodium chlorate (2 lbs. to a gallon) ; Sodium chloride (3½ lbs. to a gallon) ; Borax (½ lb. to a gallon) and Copper sulphate (2 lbs. to a gallon) are fairly well known. Also, Butyle chlorophenoxyacetate and motor sump oil applied to the bark of trees are reported to be useful in killing trees.

In this preliminary investigation on Fernoxone, three methods of application of the chemical to trees were tried :—(1) A frill was made in the sapwood of the tree all round and filled with an aqueous dilution of the chemical ; (2) Interrupted notches were cut all round the tree trunk and these filled with the dilution as above and, (3) Holes were bored, each about ½ in. in diameter and 3 to 4 in. deep, projecting into the bole downwards and inwards at an angle of about 45°, and the chemical introduced into the holes which were subsequently filled up with water and their openings sealed off with molten wax or some wet clay. These holes were bored on the stem at a height of about 2 to 3 ft. from ground level, in two staggered rows each having 8 holes, the distance between the holes depending naturally upon the girth of the tree.

Frills and notches were not found so efficient as the holes, for the reason that the chemical is washed off from them or the water, mixed with the powder, easily evaporates leaving the dry power behind which is thus rendered doubtfully effective.

Thirty tree species were experimented with ; 7 specimens of each kind were treated, of which 5 were injected with the chemical and two were left as controls. One oz. (by weight) of fernoxone was tried on each tree. This quantity was divided into 16 equal parts and one part inserted into each hole on the treated trees. The trees which were left as controls were similarly bored into, but in their case no fernoxone was introduced ; only, the holes were sealed off with molten wax or wet clay exactly as in the case of the treated trees.

Suitable season for the treatment—The season when the treatment seems to be most effective is early spring when the annual growth is about to begin. The treatment seems to be least effective when the trees are in full leaf, in July or August.

Equipment—A small auger, a funnel and some water in a small can is all that is required for the treatment.

Precautions—Fernoxone dose not require as much care in handling as arsenic compounds. However, precaution is required to see that it does not come in contact with the eye. Hands should be carefully cleaned with soap and water after each handling ; otherwise the skin may get irritated.

Reaction of the trees—The trees in whose case the treatment was effective generally reacted as below :—

In about a week after the chemical was introduced, the portion of the bole about the points of application began to swell. At the same time the bark started shrinking and exfoliating in long fissures. The exudation of sap from the trees increased and some fernoxone was expelled from the injection holes in this process. The leaves of the trees began to show signs of wilting and, if the chemical took effect, they started shedding ; in four to six weeks the trees became almost leafless. In some trees there was no shrinking or exfoliation of the bark but the trees merely died without showing any external symptoms of reaction. Yet other trees did not respond to the chemical immediately but the action of the chemical was slow and started to be visible after about 2 months. Some trees were quite immune of the treatment and continued their growth like untreated trees.

The following gives details of the observations recorded on each species :—

Acacia catechu—The trees under experiment are 19 years old. Fernoxone was applied on 5–3–54, at the beginning of the leaf shedding season. Natural leaf-fall was generally in progress and the effect of the treatment was, therefore, difficult to distinguish. The treated trees did not give off a new flush of leaves but the controls began to bear a new flush in the last week of May. On 10th June, 1954, two of the five treated trees were found dead and the rest were dying. All are now dead.

Acer oblongum—The chemical was introduced on 14–9–52. Reaction of the trees to the treatment started within a week. Leaves curled up and dried by 18–9–52 and the trees were completely dry by 16–1–53. There was no resprouting during the following rains. This tree was also treated with ' Agroxone ' which, however, did not kill it.

Acrocarpus fraxinifolius—The age of the trees at the time of applying poison on 2nd March, 1954 was about 14 years. The action of fernoxone was not noticeable till after 6 weeks of the treatment, by which time all the trees had developed new leaves following the leaf-fall of early April. These young leaves then began to shrivel, turn yellow and drop, and by the last week of April all treated trees looked quite unhealthy. Pathological exfoliation of the bark then occurred and all the treated trees died.

Albizzia procera—The treated trees are 17 years old. The treated portions showed some swelling and excessive exudation of gum took place from the injection holes, which forced out along with it the injected fernoxone. The trees, however, continued to be healthy and normal.

Alstonia scholaris—The treated trees were about 20 years old. Fernoxone was applied on 13–9–52. No effect of the chemical was seen on the trees. There was a slight swelling round about the treated portion and bark peeled off. But, after about 5 months overgrowing of the wound by healthy tissue commenced and nearly all the trees treated are now fast covering up the holes by fresh tissue.

Araucaria bidwillii—The treated trees are about 25 years old, but have grown under suppression. The trees reacted slowly to the treatment and after 2 months the twigs began to die from their tip downwards. But, these were partly replaced by new shoots growing out of the dormant buds.

Araucaria cunninghamii—The treated trees are about 22 years old. They were affected by the treatment very slowly. As in the case of *A. bidwillii* the ultimate twigs began to die back but are still persisting in the same condition.

Bombax malabaricum—Fernoxone was injected on 11–3–54. The trees appeared to grow normally thereafter, as no set-back was noticed in their phenology, i.e., either in the date of formation of new leaves or of flower buds. But, before the leaves could develop or the flower buds mature, they began to dry up rapidly in the last week of April and by the beginning of May the trees had dropped all their leaves and flower buds. By about the middle of May all the trees were dead.

Broussonetia papyrifera—The effect of the chemical on this species was rapid and very well marked, and all the trees died within about 3 weeks of the treatment. At the time of treatment, i.e., in the begining of March, the formation of the new flush young leaves and the development of catkins was in full swing, but the effect of fernoxone was so rapid and thorough that the leaves shrivelled up as if after a severe scorching by fire and all growth activity ceased in about 10 days. There was also no swelling at the points of injection, which usually occurs in other species.

Cedrela toona—Fernoxone was applied on 4–3–54 and had very rapid action on the trees. At the time of treatment the trees were almost naked, as leaf-fall had just ended. As a result of the treatment the bark cracked longitudinally in strips and got detached from the bole. The portion of the trunk in the region of the injection developed a severe swelling and emitted a stink like that of wood-rot. After about a fortnight the trees were dead. In about a month they were completely dry.

Cupressus torulosa—Trees are 17 years old. Swelling on the trees was obseved after about two months of the treatment with the chemical, which was done on 9–4–54. The needles also shrivelled up. The trees are lingering.

Dalbergia latifolia—Trees are 28 years old. The treatment had no effect on them even after 3 months. This species was also treated with agroxone, with similar results.

Dalbergia sissoo—Trees are 25 to 30 years old. Within about a month of the treatment on 14–4–54, the leaves of treated trees began to yellow and drop off. The trees seemed to succomb to the chemical though the action was delayed. But, after some time several seemingly dead trees began to revive and give off a new flush of leaves which, however, are poorly developed and smaller than the normal leaves.

Eugenia jambolana—Treated trees are 26 years old. They have withstood the treatment well but yellowing and shedding of the leaves has started after nearly 3 months of the treatment.

Ficus glomerata and *Ficus palmata*—Old trees. These trees were not affected by the treatment. They continued to grow as usual.

Ficus religiosa—Two trees found growing epiphytically on two peach trees standing side by side were treated with fernoxone. One of them had established contact with the ground by means of its aerial roots ; this was treated on 15–4–54. In the other tree the roots had not yet reached the ground ; it was thus still completly epiphyte. This was treated on 2–4–54. At the time of treatment both the *Ficus* trees were in full leaf, though the leaves were yet tender, this being early in the warm season. By 21–4–54, i.e., within 19 days of the first treatment, the young leaves were observed to have shrivelled up and lost their lustre and the few remaining old leaves on the tree had shed. The growing tips were noted to have got bent and buckled up instead of remaining erect. After another 15 days the same symptoms appeared in the tree treated on 15th April but the effect of the treatment was comparatively slow. The tree which was treated on 2–4–54 dried up completely in about two months time (see photo).

Mallotus philippinensis.—Action of the chemical on this species is very slow and indications are that recovery is possible after a temporary set-back in growth.

Melia azedarach—Large tree, age not known. Within a month of application of the poison, the trees dried up completely.

Morus alba—Trees are 13 years old. After offering some resistance, the trees ultimately succombed to the chemical.

Ougeinia dalbergioides—Fernoxone was applied to the trees on 12th April, 1954. All the trees were found dead by 27th May, 1954.

Pinus caribaea and *Pinus longifolia*—Though good yielders of resin, contrary to expectation these succombed to the chemical more rapidly than many non-resinous, soft wooded trees. At the time of treatment elongation of the current year's shoot had taken place but the needles had not yet developed on them. After treatment, the growing tips began to droop. The development of needles stopped altogether and the old needles began to turn yellow and then brown, just as they do before the commencement of leaf-fall. By the first week of May all treated trees were dead.

Phoebe lanceolata—Fernoxone was injected on 10–4–54 but there was no visible effect till the end of May. The tree seems to resist the treatment.

Santalum album—Nature grown trees, about 10 years old. This tree fell an easy victim of the chemical. On 20th April, 1954, a small dose (30 grains) was administered to the trees (as against 1 oz. applied to other trees), but this itself proved deadly. The treated trees died in about 4 weeks. This species was also treated with agroxone which caused its leaves to shed, but the trees resprouted vigorously later on.

Sapium sebiferum—Fernoxone was applied on 14–4–54 ; this killed the tree outright by 27–4–54. The tree seems to be easily killed by the chemical.

Shorea robusta -Big trees, age not known. The chemical was applied to the trees on 15–4–54. The first effects were seen after a month (on 15–5–54) when their leaves began to wither. The trees gradually lost their growth vigor and assumed a shaggy look. The treatment was not fatal. One tree is dead, the others are alive.

Stereospermum suaveolens—Trees are about 15 years old. Fernoxone was injected on 10–4–54. Some swelling was observed in the treated portion of the bole but the trees did not show any symptoms of death. New leafing is now taking place normally.

Tectona grandis—Teak was treated on 2–3–54. Thereafter the annual leaf-fall started and the old leaves were ripe for dropping. It was, therefore, difficult to assess the results of the treatment. There was little difference between the treated and untreated trees. Pathological swelling then appeared on the treated portions of the trees. Gradually, after about 3 months, the trees appeared more and more unhealthy. The species seems to resist the treatment, as all the trees resprouted after a time. On treated trees the new leaves which emerge after the date of treatment, are characteristically crumpled (see Fig. 2). Their shape is often wiered and fantastic but, usually, the leaf looks ill developed and assumes a boat like form, convex below and concave above. What is still more interesting is the fact that sometimes the untreated trees which are standing by the side of treated ones develop such crumpled and wiered looking leaves, and for no apparent reason. Moreover, generally, only those twigs and branches which adjoin the treated tree, i.e., are growing in the direction of the treated neighbouring tree, bear such abnormal leaves. The whole matter requires closer study and investigation before an explanation for this curious phenomenon can be offered.

Ficus religiosa (*Pipal* tree) growing on *Pyrus communis* (*Naspati* tree) ; the former, treated with Fernoxone on 8-4-54 died completely by 10-6-54. The host plant is now flourishing.

Photo : Silva's collections.

A close up view of the same *Ficus religiosa* tree completely strangulating the host plant of *Pyrus communis* killed with Fernoxone. Holes were made along the periphery at 6" apart and the chemical was introduced into them. The long and deep fissures formed in the bark as a result of the poison may be noted.

Photo : Silva's collections.

Teak leaves fantastically crooked in shape, emerging from trees treated with Fernoxone; even trees adjoining the treated ones often give off such leaves.

Photo : Silva's collections.

The following is a list of treated trees classified according to the action of fernoxone on them :—

Apparently immune to the treatment given	Affected by the treatment given but not killed straight away	Readily killed by the treatment given
Alstonia scholaris	*Acrocarpus fraxinifolius*	*Acacia catechu*
Albizzia procera	*Araucaria bidwillii*	*Broussonetia papyrifera*
Dalbergia latifolia	*Araucaria cunninghamii*	*Cedrela toona*
Ficus glomerata	*Cupressus torulosa*	*Ficus religiosa*
Ficus palmata	*Dalbergia sissoo*	*Melia azederach*
	Eugenia jambolana	*Ougeinia dalbergioides*
	Litsea polyantha	*Pinus caribaea*
	Mallotus philippinensis	*Pinus longifolia*
	Phoebe lanceolata	*Santalum album*
	Shorea robusta	*Sapium sebiferum*
	Stereospermum suaveolens	

The lists indicate in a broad and general way that : (1) Trees having latex or exuding gum generally resist the treatment given. (2) Trees yielding turpentine seem to be very sensitive to the chemical.

The following table gives more particulars regarding the treatments given :—

Species	Doses	Range of diameter in	Date of applying the poison	Date of: Observing the effect for the first time	Date of: Actual death	REMARKS
1	2	3	4	5	6	7
Acacia catechu	One oz. divided into 16 parts	" 5·5–9·1	5–3–54	..	10–6–54	Quick action.
Acrocarpus fraxinifolius	,,	5·0–6·7	2–3–54	17–4–54	..	
Albizzia procera	,,	7·7–13·2	6–3–54	14–5–54	Not dead	Swelling at the point of treatment.
Alstonia scholaris	,,	..	13–9–52	25–9–52	,,	Healthy tissue is gradually covering up the wounds.
Araucaria bidwillii	,,	4·6–4·8	9–4–54	10–6–54	,,	Growing tips and leaves dried up. Older leaves are yet unaffected. Fresh shoots are emerging.
Araucaria cunninghamii	,,	6·3–8·1	21–4–54	..	,,	,,
Bombax malabaricum	,,	5·0–12·5	11–3–54	7–5–54	27–5–54	All trees dead.
Broussonetia papyrifera	,,	6·0–11·2	5–3–54	25–3–54	5–4–54	Apparently no swelling at the point of application of fernoxone.
Cedrela toona	,,	6·7–11·7	4–3–54	25–3–54	17–4–54	Swelling has occurred at the point of treatment.
Cupressus torulosa	,,	6·0–8·5	9–4–54	..	Not dead	Slow; trees appear to be reviving.
Dalbergia latifolia	,,	7·0–9·5	14–4–54	12–5–54	,,	No action.
Dalbergia sissoo	,,	12·0–16·0	14–4–54	12–5–54	,,	Leaves shed, but a new flush has appeared.
Eugenia jambolana	,,	6·0–9·3	13–3–54	..	,,	Trees are healthy.
Ficus glomerata	,,	..	15–5–54	..	..	No action.
Ficus palmata	,,	..	15–5–54	..	..	No action.
Ficus religiosa	,,	5·5–10·0	2–4–54 15–4–54	22–4–54 6–5–54	..	Dead.
Litsea polyantha	,,	6·0–8·7	8–3–54	5–4–54	..	Delayed action; trees have resprouted.
Mallotus philippinensis	,,	6·3–9·8	14–4–54	12–5–54	..	Struggling; likely to revive.
Melia azedarach	,,	..	21–4–54	21–4–54	27–5–54	..
Morus alba	,,	4·5–7·0	10–4–54	10–6–54	..	Trees dead after some delay.
Ougeinia dalbergioides	,,	..	12–4–54	21–4–54	27–5–54	..
Pinus caribaea	,,	..	12–4–54	21–4–54	27–5–54	..
Pinus longifolia	,,	6·4–7·3	10–3–54	5–4–54	8–5–54	..
Phoebe lanceolata	,,	5·0–6·2	10–4–54	27–5–54	..	Trees have recovered.
Santalum album	30 gr.	..	20–4–54	..	30–5–54	Quick action.
Santalum album	Agroxone ½ oz.	..	20–4–54	15–5–54	Not dead	Resprouted.
Sapium sebiferum	Fernoxone 1 oz.	8·0–12·3	14–4–54	1–5–54	27–5–54	Rapid death.
Shorea robusta	,,	8·6–13·5	15–4–54	..	..	Slow action. One tree dead.
Stereospermum suaveolens	,,	9·2–11·9	10–4–54	14–5–54	Not dead	Swelling.
Tectona grandis	,,	6·3–9·3	2–3–54	17–4–54	..	Trees have revived.

A second dose of fernoxone will probably kill most of the trees which have survived the effects of the first dose.

The fatal effect of the single, 1 oz. dose of fernoxone on *Ficus religiosa*, the *pipal* tree, is likely to be of considerable practical utility to foresters, engineers and archeologists as this tree is responsible for damage to a large number of temples, monuments, bridges and old houses all over the country.

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II

Inducing heartwood formation in the Indian sandalwood tree, *Santalum album*, Linn.

The home of sandalwood in India is the Deccan tableland. The trees are found in most parts of Mysore and portions of Madras, Coorg, Bombay and Hyderabad. Along the western coastal strip of the Arabian Sea there is a certain amount of sandal, but the formation of heartwood here is stated to be not very satisfactory.

The most satisfactory growth of the tree from the point of view of heartwood formation takes place on the Deccan tableland, which is situated at a height of about 2,000 feet above sea-level. The soil here is of the red loam or black cotton type, and the rainfall varies between about 20 and 40 inches. There is no frost.

Sandal has been widely introduced into various parts of India and also into countries outside India. The erstwhile princely state of Gwalior, perhaps, introduced it very long ago, so much so that its introduction is lost in antiquity, and some people, therefore, claim it as being indigenous to that part of India. About 18 to 20 years ago, Japan probably introduced sandal into the island of Formosa.

An outstanding peculiarity connected with the growth of the tree is stated to be that, outside its natural home, the tree does not form any heartwood or, even if it does so, such formation is of a meagre quantity and poor quality. We have yet to verify the reliability of this statement by actual investigation, but the fact remains that the sandal trees which were planted in New Forest, Dehra Dun, in 1938 showed no traces of heartwood when they were examined in 1950, although some of the trees had already attained about a foot in girth. The seed for the above plantation was imported from Madras State, and the plantation was raised by planting out potted plants.

It is obviously useless to grow the tree if it does not form heartwood readily in its new place or does so only indifferently. In New Forest the tree has been seeding copiously year after year, from an early age ; it is also spreading naturally, and to-day we find seedlings, saplings and young trees practically all over the Silviculturist's Research Garden and Demonstration Area. (Elevation 2,000 ft., soil clayey loam, rainfall 80 in., winters mild with occasional frost but the temperature rarely goes down to the freezing point). All the trees look very healthy, in fact they are exceedingly healthy and the growth is also fairly fast. A very interesting fact noticed in connection with the sandalwood trees here, is that there are two distinct growth habits among them ; in one, the branches and the leaves are normal and more or less erect, just as in most of the trees in its own home (Fig. 1), in the other the branches are distinctly pendulous (Fig. 2) and they remind one of a Weeping Willow, although they are not so distinctly drooping. Both these had not produced any heartwood until 1950, when they were carefully examined with the help of a Pressler's Borer.

With a view to see if formation of heartwood can be induced in the sandalwood trees growing in New Forest, an experiment was started in 1950, when the trees were only 12 years old, which consisted of the following treatments :—

(1) Injections of Seradix A., a plant harmone, in aqueous solution.
(2) Injection of 1% aqueous solution of zinc sulphate.
(3) Injection of 1% aqueous solution of copper sulphate.
(4) Injection of 10% sulphuric acid.
(5) Lopping the trees as is done in localities where it is severely lopped for fodder.
(6) Boring through the stem with an auger similar to the boring of beetles which often occurs in nature.
(7) Partial girdling.
(8) Incomplete ringing of the bark (debarking).

(9) Dealing mechanical blows on the stem to simulate the bad treatment meted out to the tree in various parts of its own home.
(10) Root pruning.
(11) Control – (no treatment).

Preliminary work—At the outset, the trees in the plantation were all enumerated and their diameters recorded. Comparable sets of trees of all the diameter ranges available were selected for each treamtent, with a view to eliminate the possibility of tree-diameter playing its own part in the formation of heartwood. The trees were then allotted at random to the treatments, under the advise of the Statistician, in order to eliminate all bias which might vitiate the observations to be subsequently made. Mechanical injury such as lopping, administrating blows to produce jamming of the tissue, partial girdling, ringing of the bark, root prunning, boring, etc., was done in the usual way. The trees were lopped with a sickle. For purposes of jamming, blows were administered on the stem with a heavy steel hammer. For girdling, two half-moon shaped girdles were made on the tree one below the other so that the ends overlapped each other. For root pruning treatment the soil along the main roots were carefully laid bare and 50% of the main roots were cut at a distance of about 1½ ft. from the junction of the bole and the roots. Injections of the chemicals and plant harmones was done by boring holes into the stem, inwards and downwards, slanting at an angle of 45°, with the help of a carpenter's auger, and measured quantities of the solutions of the chemicals were introduced into holes which was then sealed off carefully from the air with molten wax. Before treatment, spans of wood were extracted from each tree in the portion where the tree bole passes on to the root (region of the hypocotyl) as well as from the main roots themselves. These were carefully examined to make sure that there was no heartwood in any of the treated trees or in the controls.

Treatments—These were started in 1950, and they were repeated year after year till 1953. Also, each year, at the end of the growing season borings were taken out of each tree with the help of Pressler's borer and carefully examined for traces of sandal heartwood, fist macroscopally under a powerful lens and subsequently, in cases of doubt, also under a microscope, to find out if heartwood formation has commenced as a result of any of the treatments. The unmistakable presence of sandal heartwood which is recognized by its characteristic smell was naturally relied upon to recognize the commencement of formation of heartwood. This was, generally, in addition to the other tests mentioned above.

The following observations were made year after year including the current year, i.e., 1954, which is the 5th year including the first year of treatment :—

Treatment	Tree No.	Diameter (in.)	Heartwood formation	Remarks (condition in August, 1954)
(1) Seradix–A (15 c.c. in 200 c.c. of water)	43	2·2	Fair	
	56	2·9	Fair	
	59	2·1	Abundant	..
	79	3·0	Abundant	
(2) Zinc sulphate 1% aqueous solution	54	1·8	Fair	
	66	3·0	Abundant	
	71	2·8	Fair	..
	77	4·0	Abundant	

(*contd.*)

FIG. 1.
Sandal tree with drooping habit,
F.R.I. New Forest.
Photo : Author.

FIG. 1-A.
Close up of the branches of the Sandal tree with
the drooping habit, F.R.I. New Forest.
Photo : Author.

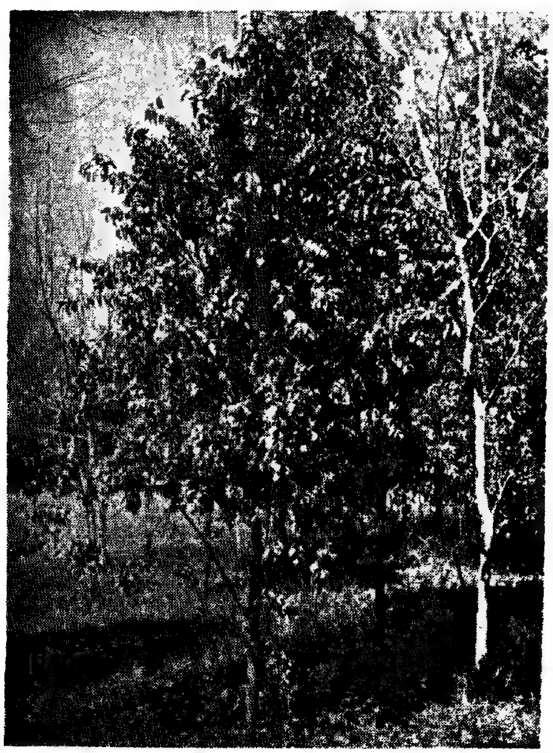

FIG. 2.
Sandal tree with normal habit (no drooping of
branches), F.R.I. New Forest.
Photo : Author.

FIG. 2-A.
Close up of the branches of the Sandal tree with
the normal habit, F.R.I. New Forest.
Photo : Author.

Treatment	Tree No.	Diameter (in.)	Heartwood formation	Remarks (condition in August, 1954)
(3) Copper sulphate 1% aqueous solution	4	1·7	Fair	In one case heartwood formation has taken place, giving a core of heartwood, but this core is not continuous because of the corrosive action of the chemical on the plant tissues.
	6	2·4	Abundant	
	32	3·2	Fair	
	50	3·8	Fair	
(4) Sulphuric acid, 10%	9	2·5	Killed by the treatment	In No. 78 the plant tissue was found destroyed at the core of the tree; a trace of heartwood was found at the periphery of the destroyed plant tissue.
	28	1·8		
	45	2·3		
	78	3·1	Traces	
(5) Lopping	12	2·1	..	No heartwood in 41 and 57. Traces found in 12 and 76.
	41	2·1		
	57	2·5		
	76	3·0		
(6) Boring through with an auger	9	2·4	..	Abundant heartwood found in trees 68 and 80. No heartwood in 29 and 9.
	29	1·8		
	68	3·0		
	80	3·3		
(7) Partial girdling	18	1·6	..	No heartwood in any tree.
	53	2·2		
	65	2·1		
	84	3·3		
(8) Incomplete ringing of bark	36	2·1	..	No heartwood in any tree.
	55	1·9		
	58	3·7		
	70	1·7		
(9) Mechanical blows	8	2·0	No heartwood	
	11	2·0	No heartwood	
	2	2·3	Traces	
	64	2·4	Traces	
(10) Root pruning	20	1·5		Traces of heartwood found in tree Nos. 20, 42 and 81. No heartwood in No. 67.
	42	2·2		
	81	3·0		
	67	2·2		
(11) Control	1	2·8	Nil	No heartwood in the trees except in 69 where doubtful traces of it were found in one place, possibly owing to a local injury.
	15	2·1	Nil	
	27	2·9	Nil	
	69	3·9	Traces	

Abundant=Where the core of heartwood found is about an inch or more in diameter.

Fair=Where the core is about ½ to 1 in. in diameter.

Traces=Where the core is less than ½ in. in diameter.

Nil=Where there is no heartwood.

Tentative conclusions—Under the conditions of soil and climate obtaining in the Silvicultural Research Garden, New Forest, Dehra Dun, it has been found possible to induce the formation of a distinct core of sandal heartwood, an inch or more in diameter, in young (12-year old) sandal trees, by subjecting the trees to annually repeated injections of aqueous solutions of the plant harmone seradix A ($7\frac{1}{2}\%$ solution), Zinc sulphate (1% solution) and copper sulphate (1% solution). The same result may sometimes be achieved by making bore holes through the trees, but heartwood formation is generally confined in such cases to the viscinity of the bore holes. Traces of heartwood formation can also be induced by injury treatments like root pruning, lopping and, sometimes by dealing mechanical blows on the surface of the trees which jam the superficial living tissue.

These experiments are likely to be of considerable practical utility in those localities where the formation of sandal heartwood is meagre if not indifferent, inspite of the fact that the tree grows luxuriously.

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ROAD BEAUTIFICATION

BY HARDEVI KARAMCHANDANI, M.A.
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This short article is devoted to a non-technical subject on the desirability of planting trees and otherwise improving our modern roads. Who has not felt the difference while travelling between a roadside cooled by a canopy of leaves and one devoid of any tree growth ? When one comes across sections of tree shaded roads, can one deny the satisfaction these green lanes of diffused light give the traveller ? They invariably leave a pleasant impression on our minds showing what might be a delightful rule and not the rare exception.

Beautifying roads by tree-planting is no new idea. In our country the importance of shady trees along the roadside has been recognized and practised since ages. The neglect has been more in our times – ours has been an era of shade tree destruction and roadside desecration. This has resulted in our roads becoming bare, dusty, windswept and sunscorched. It is not at all unusual for a traveller along the highways to come across frequent road sections bearing trees that have been hacked down time and again leaving only the ghosts of what once were beautiful shady trees. Planting of roadside trees is no doubt the obligation of Government and its agencies but their maintenance and preservation are positively a public responsibility. If the desire to establish and preserve these trees once finds lodgement in the public mind – such a desire would appear to be the natural reaction of every traveller who gives the slightest thought to the subject – roadside planting will take care of itself. When we consider the universal desire of not only a trudging pedestrian but even the most "speed-mad-motorist" to park his car in the shade, it is hard to understand how the need for roadside trees has been neglected.

Apart from the aesthetic values of roadside trees, their physical benefits are no less important in contributing towards the general welfare of the people. Such trees and shrubbery prevent erosion of roadside banks and tend to reduce road maintenance costs. Protection of the roads from sudden and extreme exposures to heat and cold provided by the tree canopy prolongs their life. This indirectly provides better surface which helps in the saving of automobile tyres and tops, and to the dust-weary travellers it means a heavenly boon.

Another factor in the construction of modern highways is one that has to do with the conservation of human life. Many accidents occur because the pedestrians insist upon walking right in the centre of the road or again because the caravans of bullock carts refuse to heed the endless horning of the motorist. Herds of cows and buffaloes too seem blissfully ignorant of the fact that roads are not for them alone. This state of affairs sometimes results in the death of the pedestrians, sometimes in the death of those in the vehicles, so both have a reason for desiring the construction of paths or sideroads, particularly along the highways most travelled. Trees along these sidepaths would greatly help in attracting the pedestrians and animals to keep to their tracks.

Pole lines are becoming eyesores too. It is impossible to properly beautify highways when one or both sides are defaced by poles and cross-arms carrying a network of wires. It would be desirable to have these located at a fair distance from the highway or the wires should be placed underground as is being done in many western countries. Fortunately in India, glaring billboards and other advertising signs have not yet spread deep into the countryside, although there is an increasing tendency towards adding this eyesore too. Commercial

advertisements near the highway offend the visual senses and distract attention. All road signs should, therefore, be removed except historical or geographical signs and those meant for the guidance and requirements of traffic.

Beauty inspires decency, ugliness begets misery ; it is, therefore, a public necessity that these much needed improvements of the countryside be incorporated while planning for better and extended highways. Treelined highways will pay large dividends. They will encourage civic pride, increase land value, reduce road maintenance, lessen accidents, equalize temperature on the roads and provide healthy recreation and enjoyment. Their creation would be a profitable social and economic investment besides making for an expansion of civic sense.

BAMIABURU CONTOUR TRENCHING EXPERIMENT

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The first experiment in India on contour trenching was initiated by Owden and Warren in 1933 near Bamiaburu. It was after considerable time that the contour trenching experiments were started in Bombay and Punjab in 1939. After two decades, contour trenching of the intensity of Gradoni system has been adopted in Bihar for all afforestation work. In Bengal also a very extensive network of contour trenching is the standard practice for all afforestation work.

Warren had put in three contour trenches at Bamiaburu 2 feet wide and 1 foot deep in an area of 15 miles in length and ½ to 4 miles in width. The first trench was on the 1,500 feet contour level. The three trenches of Bamiaburu covered a drop of 800 feet. Compared to the present system of contour trenching adopted for afforestation work in Bihar, it would appear that Warren's trenches were inadequate. Under the Gradoni system of Italy the trenches are 20–30 feet apart. The contour trenches recently adopted for afforestation work in Bihar is $1 \times 1 \times 20$ feet interrupted at 10 feet intervals along the contours and 15 feet apart from centre to centre across the contours. The dimensions of contour trenches of Bamiaburu were inadequate to arrest the run-off of water with only three continuous trenches in a height of 800 feet (1).

However, it must be remembered that those were the days of depression and Warren could not afford to have an extensive network of contour trenches. Even these three contour trenches were criticized on the grounds of costs as would appear from an extract from the Proceedings of the Fifth Silvicultural Conference (2) which runs as follows :—

> "Mr. Laurie :—The claims made for contour trenching have been given very wide publicity and have even been commented upon in European scientific journals. Although Mr. Warren does not claim finality for his results, they are stated sufficiently emphatically for the lay reader to believe in them, and as a result there is the danger of large scale contour trenching operations being started on the strength of the claims made and considerable sums of money may be spent with the possibility of ultimate disappointment".

Warren's experiments are still inconclusive as the Bamiaburu experiments were started in 1933 when the statistical requisites of adequate replications, randomization of treatments and initial comparability of the plots were almost unknown in Forestry. Inspite of the lack of Statistical finality, for all practical purposes we know now the efficacy of contour trenching in afforestating vast stretches of lands in Bihar and Bengal, and we are spending Rs. 70 per acre on contour trenching alone in our afforestation work with due satisfaction.

The claims made by Warren were rather tall as he felt convinced that the three contour trenches of Bamiaburu were responsible for meteorological alterations as well as ecological changes. Owden and Warren felt that clouds were attracted towards Bamiaburu trenched areas. In those days, the area was often inspected by the Conservators with the result that fire protection was most attended to and was really effective. *It is natural to expect ecological* and climatic changes after such a tight fire protection in those areas covered with dry sal leaves and grasses liable to severe fires in the past. The influx of sal regeneration under the effect of irrigation from those contour trenches can all be explained but improvement in quality of the forests and extensive climatic changes can never be proved on account of the

defective statistical designs of the experiment as would appear from the following records of annual rainfall figures of Bamiaburu :—

Annual rainfall data of bamiaburu, Kolhan Division

Year	Total Rainfall
	"
1937	61·9
1938	59·17
1939	38·98
1940	32·31
1941	63·77
1942	70·35
1943	54·18
1944	41·4

On account of these inherent defects of the experiment, Warren was criticized in his time for his tall claims but it must be admitted that he was an exponent in the cause of contour trenching work in India. It was a pioneer work then in those days of depression and Warren did succeed in demonstrating the efficacy of contour trenching. Now, instead of having 3 contour trenches at Bamiaburu in 800 feet drop, we have a network of interrupted trenches 15 feet apart across the contour even in comparatively flat areas. For afforestation work, these contour trenches 1×1 foot were found to be more economical rather than to dig pits. Digging pits $1\frac{1}{2} \times 1\frac{1}{2}$ feet with a crow bar is more difficult rather than to dig $20 \times 1 \times$ feet trenches with pick-axes, because in the former, one coolie can do only 20 c. ft. of earth work while in the latter he can do 40 c. ft. easily. As such, besides checking the run-off, the soil working in the shape of contour trenches is much more economical and effective for all afforestation work launched on a gigantic scale in this State.

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1. *Sahay, B. K.*, 1946. On the dimensions of contour trenches. *Indian Forester*, Vol. 72, No. 10 (October, 1946), page 487.
2. Proceedings of the Fifth Silvicultural Conference, 1939, page 457.

A DIAGNOSTIC KEY TO THE VARIOUS FORMS OF INTRODUCED MESQUITE (*PROSOPIS JULIFLORA* DC.)

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SUMMARY

This paper contains a general account of the Mesquite – *Prosopis glandulosa* Torr. and *P. juliflora* DC., including the various forms of the latter. These trees were introduced into India as very promising species useful in afforesting dry and degraded lands. A historical review of their cultivation in India is included. Observations have also been made on their distribution and economic importance. Botanical descriptions of the genus *Prosopis* and its two species, mentioned above, are given. The behaviour of *P. juliflora* as a composite species has been explained. The silvicultural characters and diagnostic features of the various forms of *P. juliflora*, including *P. glandulosa*, have been discussed and a key to their correct identification has been provided.

The usefulness of Mesquite (*Prosopis juliflora* DC.) in afforesting arid areas has long been recognized and its successful introduction into India has, of late, created considerable interest amongst foresters and others. It is considered to be the most valuable tree of the North American forests and the amount and quality of the food and fuel, which it produces in vast territories, where both are scarce, makes it one of the most valuable of all trees. It is a useful sand binder and a pioneer in afforesting dry and degraded grasslands and waste lands where more valuable species would not grow. Being of strongly xerophilous habit, it is remarkably resistant to drought and should have a big future in desert afforestation. It is a fast growing species and the conditions for its growth are simple. A hot dry climate with mild winters, a small rainfall and a clear atmosphere are said to suit it best ; but it is also reported to be able to withstand many degrees of frost and in tenacity of life and ability to struggle against adverse conditions, which would exterminate most plants, it is said to surpass many others. Being sensitive to excess of moisture, damp localities are unsuitable for its growth.

Prosopis juliflora DC. belongs to the family *Leguminosae*. It is a very variable species. It was first found within the territory of the United States, in the valley of the Canadian River near the northern limits of its distribution, in 1820, by Dr. Edwin P. James, the naturalist of the Long's Rocky Mountain Expedition. It is distributed in the United States from southern borders of Colorado and Utah through New Mexico, and northern and western Texas to Rio Grande, and through southern Nevada and Arizona to southern California. The eastern limit of its range is the neighbourhood of Dallas in Texas and then southward to the valley of the Colorado and along the gulf at a distance of thirty miles from the coast, approaching the mouth of the Rio Grande ; its western limit by a line extending from Tejon Pass in California by Los Angeles to San Pedro on the Pacific Coast. It is generally distributed through northern Mexico and Lower California, and is abundant in the Andean region, extending south as far as Chile ; widely spread in the Argentine Republic, and has become naturalized in the arid regions of southern Brazil and in the drier parts of the island of Jamaica. It was introduced into England from Chile in 1832 and is now cultivated in most of the warm, dry parts of the world.

The earliest records of Mesquite cultivation in India date as far back as 1877, but there was certain amount of confusion regarding the identity of the seeds from which the plants were

raised. In 1878 two further supplies of Mesquite seeds were received through Kew and India office but again of doubtful identity. The question of introducing the plant into India was taken up more seriously about 60 years ago, when it was planted by the Forest Department in the Pabbi Hills of Gujrat, Punjab, as a trial measure. Many years later it was discovered that the plant had successfully established itself in the enclosed areas of the Pabbi Hills. In Sholapur District Col. Corbyn reported in 1879, that he had planted 110 seedlings but no trace of these now remains. It has been found to thrive at Deoli (E. Rajasthan) and in Gurgaon district. In Jodhpur state it was first introduced in 1913, with great success and seeds were supplied by the State Forest Department to the adjoining states and to the Ajmer Forest Department. At a later date it was grown very successfully from authentically named seeds in several places in the west Punjab, such as Lahore, Montgomery and Multan districts and a small area in Jullundur district. It has been remarkably successful in Sind, where it proved a useful sand binder. It has done splendidly in Madhya Pradesh and is reported to have done well in Madras State. Recent reports from Bombay indicate that it has been successfully grown in certain parts of that state. It has reproduced naturally over the Miani plain near Hyderabad, Sindh, through seed distributed by goats which eat the pods and thus help to fix the sand and check further inroads of drifting sand. It has done equally well in Baluchistan.

It is evident from the above that the Mesquite of America is gaining popularity in India day by day. It is not only useful to the forester but, it is hoped, that it will prove of immense value to the agriculturist also in times to come. It can be grown as a tree, shrub or hedge. Cattle have a distaste for its leaves and twigs and they ordinarily do not touch them but the ripe pods are greedily eaten by most of the herbivorous animals. Ripe pods are said to be of high nutritive value ; they are rich in sugar and nitrogen and the great advantage in using the pods as fodder, is, that in some forms, they are produced twice a year. They are largely consumed by Mexicans, who grind them into coarse flour, which is baked after picking out the seeds. An infusion of the flour can be fermented and brewed into weak beer. The flowers are also a good source of honey. As for the woody portion of the tree, the poles are often used as fence posts and are said to last well in contact with soil. The timber is said to be exceedingly hard and durable. An analysis of the wood carried out by the United States Department of Agriculture, shows 6·21% of tannic acid in the heartwood and 0·50% of the same in the sapwood and bark. An astringent decoction obtained by boiling chips of the heartwood may be used to check diarrhoea and dysentry.

Mesquite is a legume belonging to the genus *Prosopis*, which is represented in India by two introduced species, viz., *P. juliflora* DC. and *P. glandulosa* Torr. ; the latter has been reduced to a variety of *P. juliflora* by American Botanists, a view not supported by later authors. The botanical description of the genus *Prosopis* is as follows :—

Trees or shrubs, usually armed with solitary or geminate axillary spines or spinescent stipules. Leaves bipinnate with 2-4 or rarely many pinnae, the pinnae many or few-foliolate ; petioles and petiolules usually furnished with minute or obscure glands ; leaflets often rigid ; stipules minute or wanting. Flowers small usually sessile, in axillary spikes or heads, 5 – merous. Calyx campanulate, 5 toothed or slightly 5 – lobed, deciduous. Petals connate below the middle or ultimately free glabrous or tomentose on the inner surface towards the apex, sometimes puberulous on the outer surface, hypogynous. Stamens 10, free, inserted with the petals on the margin of a minute obscure disk adnate to the calyx-tube, those opposite the lobes of the calyx rather longer than the others ; filaments filiform ; anthers oblong, versatile, introse, 2-celled, connective tipped with a minute deciduous gland or rarely eglandular. Ovary inserted at the base of the calyx, sessile or stipitate, villose or glabrous, many ovuled ; style filiform, tipped with a minute stigma. Pod linear, compressed or subterete, straight, falcate, contorted or twisted into a more or less regular spiral, indehiscent ; exocarp thin or coriaceous ; mesocarp thick, spongy, or hardened, rarely thin ; endocarp cortilaginous or papery forming partitions between the seeds or surrounding each seed separately, or rarely the pod almost continuous within. Seed usually ovoid, compressed.

About 17 species are distinguished, distributed from the southern borders of the United States to Patagonia, occurring in tropical Africa in the Orient and in tropical and sub-tropical Asia.

The botanical description of the species is as follows :—

Prosopis glandulosa Torr.—A small or medium-sized, deciduous tree, branches long, zig-zag, straggling or pendulous, armed with scattered axillary, stout, subulate thorns 0·5–2 inches long. Rachis 1–5 inches long, slender, terete, prolonged beyond the last pinnae as a soft bristle, swollen and glandular at the base. Pinnae usually 1-sometimes 2 pairs, 3–5 inches long, often glandular between the leaflets. Leaflets 10–18 pairs, ·7–2 inches long, rather distant, linear-oblong, falcate, usually acute, midrib almost central, sub-sessile. Flowers creamy-white, in axillary pedunculate spikes about 3 inches long solitary or in fascicles of 2–4. Calyx campanulate, 5-toothed, teeth ciliate, otherwise glabrous. Petals 0·15 inch long, oblong, villous within towards the tips. Pod 5–8 by 0·3 inches, linear straight or falcate, compressed, turgid usually with a long stout beak. Seeds 12–20, ovoid, compressed.

Prosopis juliflora DC.—The earliest botanical account of *P. juliflora* was published in 1788 by the Swedish traveller Swartz, who had found it naturalized in Jamaica.

A small evergreen tree, branches long, spreading, usually unarmed. Rachis 1·5–2·5 inches long, sparsely hairy, prolonged beyond the last pair of pinnae as a soft point, often bearing a gland between each pair of pinnae. Pinnae 2–4 pairs, 1·5–2 inches long, sparsely hairy. Leaflets 10–46 pairs, 0·2–0·8 inches long, oblong, minutely mucronate, midrib almost central, sessile. Flowers pale cream-coloured, in axillary spikes 3–5 inches long. Otherwise as for *P. glandulosa*.

Economically this plant appears to resemble *P. glandulosa* but possesses the additional advantage of being evergreen. It is very hardy and grows fast and is likely to be even more useful for afforesting arid ground than *P. glandulosa*.

Up to 1912 there was only one form under cultivation in Lahore, namely, the deciduous *P. glandulosa*, but five more forms of *P. juliflora* were introduced later and they are *P. juliflora – Argentine form, Arid form, Mexican form, Peruvian form* and *Australian form*. These five forms of *P. juliflora* including *P. glandulosa* have been planted in India primarily on an experimental basis so far. All these forms were reported to be regenerating naturally in the Punjab ; so conditions there evidently suit them. Mohan reports that a few other species of *Prosopis* including some other forms of *P. juliflora* were under trial in the Silvicultural Experimental Garden, Chichawatni, West Punjab. But, no records are now available to indicate how far these under trials, viz., *P. juliflora* var. *velutina*, *P. juliflora* var. *Texas*, *P. nigra*, *P. pubescens*, *P. strombocarpa*, etc., have been successful.

Prosopis juliflora DC., as defined by Bentham and others, is a composite species. After excluding the deciduous *P. glandulosa* Torr., there remain a number of forms, referred to above, differing more or less in foliage and habit and pods but not in their flowers. Regarding their silvicultural behaviour they are so much at variance that it is all the more necessary to distinguish them. *P. glandulosa* is a deciduous species whereas the different forms of *P. juliflora*, are evergreen to semi-evergreen. The *Argentine*, *Arid* and *Mexican* forms are reported to be frost hardy but the *Australian* form is susceptible to frost, specially when young. The *Peruvian* form has been found to be more sensitive to frost them the *Australian*. The *Arid* form is said to do well in very dry situations ; therefore irrigated land will not suit it. The *Mexican* form will grow better on shallow rocky soil, while the *Peruvian* form requires good drainage and should therefore be grown on high ground rather than in depressions, but the *Argentine* form thrives well in clay saline soils and needs irrigation. The *Australian* form is the one to choose if the pods are required as fodder as it gives two crops a year, one about May, the other in November. For forest plantations the frost hardy species may be taken into consideration and are to be recommended. The shrubby forms may possibly serve as hedges round agricultural fields. The quick growing bushy forms may be planted for firewood. The bigger tree forms with thicker stem might perhaps be used for the extraction of timber and the smaller tree forms might find use as poles or posts.

In view of the necessity to distinguish the different forms of *P. juliflora* an attempt has been made in this paper to evolve a key to their identification, which is based, among

other characters, primarily on the character of the pods. Field characters such as the deciduous nature of *P. glandulosa*; the *Australian* form flowering twice a year; the *Argentine* form becoming leafless for about two months in the year and so on are quite as important in their determination. Certain other features, which are helpful in their diagnosis, are – the largest number of close set leaflets (25–46 pairs) in *Argentine* form, at once separates it from the other forms, which have lesser number of leaflets (Pt. I, Fig. 1); the leaflets of *P. glandulosa* are generally the longest in size (0·7″–2″ long) and distantly set (Pt. I, Fig. 4); so there will not be much difficulty in distinguishing this form by its foliage, unless it gets mixed up with the longer leaflet forms of the *Mexican* variety, which has in some cases somewhat similar leaflets. Of the five forms of *P. juliflora*, viz., *Argentine, Arid, Mexican, Peruvian* and *Australian*, the *Mexican* form has the longest sized leaflets (Pt. I, Fig. 3), hence it can be conveniently separated from the other forms on its foliage character alone. The *Arid* form is almost always with one pair of pinnae at the nodes (Pt. I, Fig. 2) – but this is not a very constant character to be relied upon always. In the case of the *Mexican* form there is almost always a prominent cupulate gland at the junction of pinnae, though this structure is present in the case of the other forms as well, rather irregularly. Glands are present at the junction of the pinnae as well as at the union of the leaflets in the case of *Argentine* and *Peruvian* forms. The structure of the pods is often quite characteristic for each of the forms. The stoutest and largest sized pods of the *Argentine* form distinguish it from the rest of the varieties, in which the pods are comparatively much short and slender (Pt. II, Fig. 1). The distinctly beaded nature and the narrow outline of the pods of the *Arid* form make it easily recognizable; the pods in this case are, moreover, smallest in size, especially in width (Pt. II, Fig. 2). The pods of the *Mexican* form are, though beaded but not regularly so as in the *Arid* form and are comparatively big in size (Pt. II, Fig. 3). But the pods of the *Mexican* form are apt to be confused with those of *P. glandulosa* (Pt. II, Fig. 6). The pods of the latter are somewhat bigger in size, though infrequently the pods of *Mexican* form and *P. glandulosa* may be more or less of the same size. There is a good deal of similarity in the structure and colour of the pods of these two species, but the beaks of the pods of *P. glandulosa* are remarkably stouter and bigger than those of the *Mexican* form, a feature, which makes them differentiable. The pods of the *Peruvian* form are perfectly smooth, cylindrical and somewhat curved and are never beaded unlike the two forms mentioned above and the septation of the pods is never pronounced (Pt. II, Fig. 4) in addition the pods are of shiny appearance and often prominently longitudinally striated on the surface. These characters combined with its more or less stout beak separate it from the *Australian* form in which too the pods are scarcely beaded (Pt. II, Fig. 5). The pods of the *Australian* form are generally distinctly septate and the most striking feature about them is that the pods are furnished with very short beaks, probably smallest of all the forms. The beaks of the pods in the *Argentine* form are shaped like the blade of a grafting knife. The pods of the *Arid* form have striaght, somewhat cylindrical pointed beaks. In the *Mexican* form the beaks are more or less sickle-shaped and in the *Peruvian* form they are subulate. The beaks in *P. glandulosa* are stout, cylindrical and long, markedly longest of all the forms. Some more morphological observations on the different forms of *P. juliflora* are :—

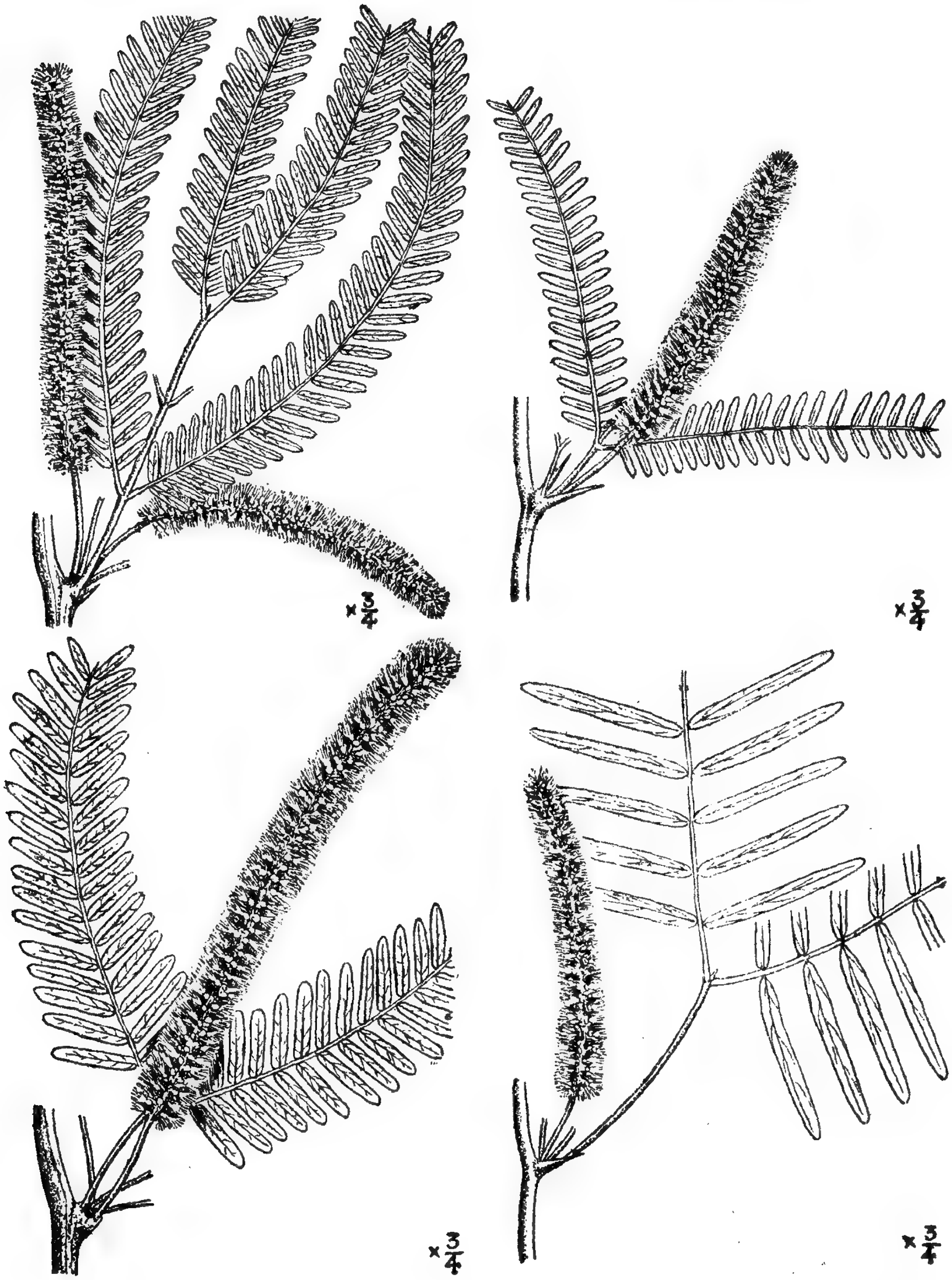
Argentine form—Leaves single or in clusters at the nodes, with 2–3 pairs of pinnae; petiole 1″–2·2″ long, pinnae 3″–5″ long; leaflets 25–46 pairs, 0·2″–0·4″ long, somewhat close set, glabrous, apex acute to acuminate, more or less densely ciliated on the margins: rachis glabrous to hairy; glands present at the junction of the pinnae and uncommonly at the junction of the leaflets. Inflorescence often 2 at a node, uncommonly 3; spike 2·5″–4″ long; stalk glabrous. Pods 7″–9″ × 0·55″–0·75″, straight to curved, 17–27 seeded.

Arid form—Leaves single or in clusters at the node, usually with one pair of pinnae, rarely 2; petiole 0·2″–1·3″ long; pinnae 1·3″–4·8″ long, leaflets 16–25 pairs, 0·2″–0·5″ long,

PL. I

PROSOPIS JULIFLORA DC.

1. ARGENTINE FORM 2. ARID FORM



3. MEXICAN FORM 4. PROSOPIS GLANDULOSA TORR

PL. II

MESQUITE PODS

PROSOPIS JULIFLORA DC.

1. ARGENTINE FORM 2. ARID FORM 3. MEXICAN FORM

4. PERUVIAN FORM 5. AUSTRALIAN FORM

6. PROSOPIS GLANDULOSA TORR.

more or less wide spaced, glabrous, apex obtuse. Inflorescence usually single at a node; spike about 3″ long; stalk minutely hairy. Pods 5″–7·5″×0·3″–0·4″, straight or very slightly curved, more or less cylindrical or somewhat quadrangular, 12–24 seeded.

Mexican form—Leaves generally clustered at the node, with 1–2 pairs of pinnae; petiole 1″–3·5″ long; pinnae 2″–4·5″ long; leaflets 10–18 pairs (commonly 14–18 pairs), 0·4″–0·8″ long, somewhat wide spaced, often hairy, as also the rachis, ciliate on the margins, mucronate, prominent cupulate gland often present at the junction of the pinnae. Inflorescence 2 or more at a node; spikes up to about 5″ long, stalk hairy. Pods 7″–9″×0·35″–0·45″, septated, purplish, straight or very slightly curved, somewhat flat, cylindrical or quadrangular, 20–24 seeded.

Peruvian form—Leaves clustered at the node, generally with 2 pairs of pinnae, uncommonly 1 or 3; petiole 0·5″–0·7″ long; pinnae 1·5″–2″ long; leaflets 13–17 pairs, 0·3″–0·4″ long, somewhat wide spaced, sparsely to densely hairy, ciliate on the margin, mucronate; rachis hairy; often glandular at the junction of the pinnae and leaflets, gland small, knobby or cupulate. Inflorescence usually 2 at a node; spikes up to 5″ long, stalk hairy. Pods 4″–7·5″×0·45″–0·5″, straight, cylindrical to flat, indistinctly septated, somewhat longitudinally striated on the surface, 15–30 seeded.

Australian form—Leaves generally clustered at the node with 1–2 pairs of pinnae; petiole 0·5″–0·8″ long; pinnae 1·5″–2″ long; leaflets 13–20 pairs (commonly 19 pairs), 0·3″–0·5″ long, somewhat close set, glabrous, sparsely ciliate on the margins, mucronate; rachis glabrous; irregularly glandular at the junction of the pinnae. Inflorescence 2 or more at a node; spike 2″–4″ long, stalk pubescent. Pods 7″–10″×0·4″–0·5″, straight or very slightly curved, flat to somewhat quadrangular, septated, 25–34 seeded.

Prosopis juliflora DC. var. *velutina* Sarg., indigenous to Southern Arizona and Sonora, is described as a tree 60 ft. high and 2 ft. in diameter and has occasional reference in the literature on Mesquite, as a variety under trial in India and of some value. There are a few specimens of the plant in the Forest Research Institute herbarium also, collected from the Punjab. The most striking feature of the plant is its hairiness. The foliage and inflorescence are densely hairy and there should not be much difficulty in isolating it from the other forms.

The key below has been drawn on a study of the plant material supplied by the Silviculturist, Punjab. He had tested the applicability of the key in the field with satisfactory results. It is hoped that the key will work satisfactorily for all the forms, except the *Mexican*, which, being of very variable nature might present certain amount of difficulty in its detection. The *Mexican* form, by some authors, is regarded not to represent a pure line, since it assumes different forms in nature – some being shrubby, some small trees and still others big trees; some are evergreen and others semi-evergreen and so on. This form is suspected to be undergoing hybridization thus creating more complications in its detection.

The applicability of the key in the field, will have to be tested more thoroughly in various parts of India, where the different forms of *P. juliflora* have been grown, before the key can be declared as final. There may still be some scope for amendment in the key. Accordingly, the co-operation of various Forest Officers and private individuals, who may have the opportunity of testing the key in the field, is sought, by way of comments and suggestions, in evolving a more satisfactory key in future. Any such help will be duly acknowledged.

Our thanks are due to Shri N. P. Mohan, Chief Conservator of Forests, Punjab, for kindly going through the manuscript and offering valuable suggestions as also to the Silviculturist Punjab for testing the key in the field.

KEY

X—Leaves and inflorescence densely pubescent........................*Prosopis juliflora* var. *velutina.*

XX—Leaves and inflorescence more or less glabrous—

Y—Deciduous species, leaflets 0·7–2" long.................................. *Prosopis glandulosa.*

YY—Evergreen to semi-evergreen species, leaflets 0·2"–0·8" long..................... *Prosopis juliflora.*

I—Pod always flat, septate, mature pod more than 0·5 in. wide, beak 0·3"–0·4" long, flat, shaped like the blade of a grafting knife. Leaflets 25–46 pairs........*P. juliflora – Argentine form.*

II—Pod flat, terete or quadrangular, mature pod less than 0·5" wide, rarely 0·5" wide. Leflets 10–25 pairs.—

A—Pod usually long-beaked and beaded.—

Pod usually distinctly beaded, beak 0·3"–0·7" long, straight, pointed, somewhat flat or cylindrical..*P. juliflora – Arid form.*

Pod indistinctly and interruptedly beaded, beak 0·3"–0·5" long, stout, more or less terete, straight to somewhat sickle-shaped................*P. juliflora – Mexican form.*

AA—Pod usually long-beaked somewhat sickle-shaped, not beaded, beak 0·2"–0·9" long, generally long, both terete and flat, straight-pointed and subulate..........*P. juliflora – Peruvian form.*

AAA—Pod almost always very short-beaked not beaded, beak 0·05"–0·3" long stout, very short and pointed, slightly curved at times..................*P. juliflora – Australian form.*

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THE GRASSES OF MADHYA PRADESH

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(*Continued from* Indian Forester, *October 1954, page 611*)

XXI. CYNODON, Pers.

Spkts., closely secund on digitate spikes, one-fid, awnless, glume (i) and (ii) persistent.

60. *C. dactylon* Pers. ; *Dub* grass. Common.

A common grass in moist areas specially on black cotton soil sending out long suckers ; height up to 18″. Spikes 1″–2″ long, thin, wiry.

Perennial ; a good fodder grass ; suitable for lawns. Flrs. most of the year according to locality.

Two varieties have been collected ; (i) in which paleas are as long as the lower glume, (ii) in which the lower glume is about half of palea. The plant is easily distinguishable in the field by broader and denser spike.

A third variety in which the leaves are erect, stiff and the spikes are larger and curved has also been collected.

XXII. CYRTOCOCCUM Stapf.

61. *Cyrtococcum trigonum* A. camus. Bailadilla 3000′ ele. Bastar.

An erect stiff grass with small panicle ; leaves lanceolate. Mesophyte to marshy, growing along *nallahs.*

Perennial. Flrs. January–March.

62. *C. patens* A. camus. Along Machwada–Dodi, Mohlai, Bastar.

A decumbent grass, rooting at nodes and forming tufts along *nallahs* ; leaves linear lanceolate ; leaf axil marked out by long white hairs. Spkts. very sparse on very effuse and capillary panicle as in the case of *P. montanum.*

Perennial ; dies back in summer ; useless as fodder. Flrs. September–November.

XXIII. DACTYLOCTENIUM

63. *Dactyloctenium aegypticum* Beau. ; *Kakrrya, Gujri* (Hindi). Chanda, Mandla, Bastar.

A small grass, height up to 15″, common in grassland and fields. Inflr. of 1 to 4 thick, digitate spikes ½″ to 1½″ long and quite broad. Rachilla produced beyond the spkts. Spkts. arranged in 2 series facing downwards.

Annual ; valuable fodder grass ; seeds ground into flour and made into cakes and eaten in times of scarcity. Flrs. September–October.

XXIV. DESMOSTACHYA Stapf.

64. *D. bipinnata* Stapf. ; *Kusha* (Hindi). Mandla and Bastar.

A coarse grass growing in sal blanks ; height up to 2′. All parts of the plants stiff and fibrous. Infl. of racemosely arranged biseriate awnless spkts.

Perennial ; used for thatching and in sacred ceremonies of hindus. Conspicuous by its flowering in May–June after forest fires and few showers of rain. Not good fodder.

XXV. DIECTOMIS Hack.

Infl. of solitary spatheate spike ; pedicels of pedicelled spkts. white hairy. Sessile spkts. laterally compressed, long awned.

65. *D. fastigata* H. B. and K. Mandla, Chanda, Bastar.

A very variable grass 9″–5′ in height, growing on lateritic, sandy and poor soils in open grassland, much fastigiately branched. Spikes pendant and copper coloured.

Perennial ; not good fodder. Flrs. October–December.

XXVI. DICHANTHEUM Willem.

Spikes digitate, rarely solitary, espatheate ; lower pairs of spkts. differing from all those above them, homogamous or neuter.

66. *D. annulatum* Stapf. ; *Chhoti-Marvel, Nandi* (Hindi). Chanda, Mandla, Bastar.

A leafy small grass up to 2′ high ; peduncles and the stem below the infl. glabrous ; pedicel of the stalked spkt. about half of the sessile spkt. spikes 2 to many.

Perennial ; a good fodder grass. Flrs. August–November. There are two varieties : (i) Inflr. very much copper coloured and the glumes covered throughout with white hairs, tubercle-based or not. (ii) Infl. pale with very long stiff, tubercle-based, silky hairs mostly from the margins of the glumes.

Ecological variety ; Sheet No. 67. Mothi-Marvel, Badikel, Chutial-toker (Madia). Common.

A leafy grass up to 18″ high. Peduncles glabrous ; pedicels of the stalked spkt. about ⅓ of the sessile spkts. spikes 1 to 3.

Perennial ; good fodder ; mostly found along the bunds of paddy fields and in *Juar* fields.

68. *D. nodosum* Willem. ; Mandla, Bastar.

A very tall and distinct grass from the above 2 species in the field, generally found in forest blanks under medium shade to open, Nodes villous or smooth or conspicuously constricted.

Spikes 1 to 4. Peduncle and the stem below it densely villous. Spkt. much bigger and less hairy than in the last 2 spp.

Perennial ; a good fodder grass. Flrs. October–December.

XXVII. DIGITARIA Rich.

Spkts. in pairs, arranged on digitate spikes, unequally pedicelled. Palea embraced by the lemma, glume (i) very short or absent.

A. Spkts. ·09″ or more long.
marginata, griffithii, ternata, wallichiana, pruriens.

B. Spkts. ·08″ or less long.
longiflora, chinesis, pedicellaris and *royleana.*

69. *Digitaria chinensis* Hom. Common.

A weak tufted grass up to 20″ high ; seeds black ; spkts. ·06″– ·08″ long. Leaves linear.

Perennial ; common in wet places and places bordering marshes. Flrs. August–November. A good fodder.

70. *Digitaria griffithii* Stapf. ; *Sika* (Halbi), *Rai, Mullar* (Hindi). Common.

Comparatively robust ; up to 3′ high ; Rachis trigonous, upper glumes and barren lemmas more or less silky hairy ; hairs not clavate-tipped.

Perennial ; common in grassland, on bunds of fields, etc. A fair fodder. Flrs. August–October.

71. *D. longiflora* Pers. Common.

Culms tufted, from a geniculate often, rooting base ; spikes 2 to 3. Fruiting lemmas pale ; leaves ·5″– 2·5″ long.

Perennial ; in nurseries, on sandy-loam soil ; a good fodder grass. Flrs. August–December.

72. *D. marginata* Link. var. *fimbriata* Stapf. Common.

Similar to *D. griffithii* except rachis flat ; leaf sheaths with few tubercled, long hairs ; glumes long, silky ; back of glume (ii) smooth.

Perennial ; in grass and wasteland. Flrs. September–November. A fair fodder before flowering.

Ecological var. (Sheet No. 73). Back of glume (ii) white silky and the margin, spread out and stiff.

74. *D. pedicellaris* Prain ; *Bondrya* (Hindi). Common.

A weak grass coming up sporadically in the grassland protected from heavy grazing. Glumes white silky ; pedicels 2 to 3 nate, unequal, much longer than the spkts. which are quite gibbous ; grain brown marked by close parallel lines. At the time of flrg. in the field, the red stigmata are very conspicuous.

Annual. Flrs. October–November.

75. *D. pruriens* Buese. Common. Mandla (ele. 2000′).

Comparatively a robust grass with tufted culms from a geniculate rooting base ; spkts. medium-sized, i.e., ·08″ to ·09″ and smaller than in *D. griffithii ;* outer glumes, white silky with brown stiff hairs on the margins.

Perennial ; fair fodder. Found in forest blanks in open and under medium shade. Flrs. October–December.

76. *D. royleana,* Prain ; *Korila, Kankri* (Hindi). Common.

A tufted grass with very thin and long and digitate spikes, grain black, striolate ; spkts. ·04 to ·05″ long which is the smallest in the genus. Glumes covered with very minute, clavate-tipped hairs.

Perennial ; good fodder ; common in grassland. Flrs. October–November.

77. *D. ternata* Stapf. Chanda.

A weak grass up to 18″ high ; hairs on the glumes clavate-tipped. Spkts. ·09″ to 0·1″ long ; rachis flat, leaves linear flat and thin.

Perennial ; sporadic. Flrs. December–February.

77a. *D. wallichiana* Stapf. *Hikka* (Madia).

A tall grass up to 3′ high with leaves up to 12″ × ·5″ ; spikes 30 to 40 in number, racemosly arranged ; lower branches opposite or whorled, dividing further ; spkts. ·08″ long, glume (ii) smooth and strongly nerved, glume (i) oblong very small.

Cultivated in Mar-land adjoining Allapalli. The grain is white.

XXVIII. DIMERIA R. Br.

Spikes digitate, rachis inarticulate, spkts. falling, entire, not paired, laterally strongly compressed, shortly awned. Mostly useless as fodder.

A. Rachis of raceme terete or angled : *hohenackeri*.

B. Rachis of raceme flat.

1. Awns geniculate—*ornithopoda*, *tenera* and *bialata*.
2. Awns not geniculate—*lehmanni*.

78. *Dimeria hohenackeri* Hochst. Mandla, Chanda, Bastar.

A weak grass growing on plateaus, in open or under medium shade. Spikes 2 to 3 ; spkts. ·1″ to ·12″ long ciliate ; rachis not flat ; awn geniculate.

Annual. Flrs. October–December.

79. *Dimeria lehmanni* Hack. Bastar.

A robust tufted grass up to 18″ high, spikes 2 ; rachis flat ; spkts. 0·15″ to ·2″ long ; awn not geniculate.

Annual ; common among rocks on high hills. Flrs. September–October.

80. *Dimeria bialata* Fischer. Bastar.

A much tufted grass ; rachis broad, ciliated on both wings ; awn geniculate ; glume uniformly winged. Spkts. ·15″ to ·2″ long, densely hairy.

Annual ; among rocks in hills. Flrs. September–October.

81. *Dimeria ornithopoda* Trim. ; *San-sukhli* (Gondi). Bastar, Mandla, Chanda.

A common grass on laterite and in hills, in open or under medium shade ; rachis winged ; awn geniculate, spkts. ·1″ to ·12″ long.

Annual. Flrs. October–November.

82. *Dimeria tenera* Train. Bastar.

A very weak gregarious grass growing on laterite near ditches and water-logged *bedas*. Leaves very narrow. Rachis flat but very thin ; spkts. ·06″ to ·07″ long, nearly smooth with a few hairs at the apex of the spkts.

Annual. Flrs. October–December.

223. *Dimeria* Sp. nova. Khorgaon marsh. (Not matched in Sibpur herbarium).

A weak, decumbent grass up to 20″ long ; leaves 6″ to 8″ long, 0·1″ broad, covered with tubercle-based hairs ; nodes hairy with very thin woolly hairs. Infl. of 2 racemes ; rachis flattened and smooth ; spkts. ·18″ to ·2″ long ; keel of both the glumes ciliate on the outside, not winged though stiff and corky. Awn geniculate ·4″ long from base.

Perennial ; found in marshy places under dense shade ; ele. 2000′ rare. Flrs. November–December.

XXIX. DINEBRA Jacq.

83. *Dinebra retroflexa* Panz ; *Lona*, *Karna* (Hindi). Chanda, Mandla.

A small grass up to 2′ high with a panicle of spikes which are sometimes whorled. Spkts. unilateral, two seriate. Rachilla slender, produced beyond the uppermost floret, bearing an imperfect lemma ; glumes persistent.

It is quite common in *Juar* fields of Chanda, where the panicle is pyramidal and the spikes are deflexed. In abandoned nurseries and grasslands protected from grazing the panicle is less broad, up to 2′ long, wiry and trailing between other grasses.

Annual ; a good fodder grass. Flrs. September–October.

XXX. ECHINOCHLOA Beav.

Panicle of racemosely arranged pseudospikes, longer than the axis ; spkts. globose, biseriate, falling, entire ; glume (i) away from the axis.

A. Racemes simple ; spkts. awnless – *colona.*

B. Racemes more or less branched, glume and lemma awned or cuspidate – ***stagnina,*** *crus-galli, frumentacea.*

84. *Echninochloa colona* Link ; *Sama* (Hindi). Chanda, Mandla, Bastar. Common in all districts.

A very common grass in wastelands, ditches, fields, etc., height up to 18″ ; spkts. without awns, arranged in 2 series on panicled spikes. Spikes-longer than the axis.

Annual ; a good fodder ; it gets gradually rooted out by grazing, in over grazed areas. The grain is eaten in times of scarcity. Flrs. August–September. (i) The cultivated variety (Sheet No. 85 i) known as *sama* (Hindi) is more robust than the above, the leaf being about twice as broad ; otherwise it is very similar to the above wild type.

85. *E. frumentacea* Link ; *Ghatka* (Halbi), *Londa sama* (Hindi).

A very robust plant about 3′ tall ; the stems about 0·4″ thick ; leaf about 4 times broader than *E. colona*. Panicle very large and close. It is cultivated in Mandla and Bastar along with paddy.

86. *Echinochloa cruss-galli* P. Beauv. ; *Datya* (Hindi), *Ghatka* (Halbi). Mandla, Chanda, Bastar.

A medium-sized grass up to 3′ high, growing along *nalla* banks and margins of tanks. Ligule O ; the junction of blade and sheath brown and glabrous. Spkts. awned.

Annual ; a good fodder ; grain eaten in times of scarcity. Flrs. August–November.

87. *Echinochloa stagnina* Beauv. Mandla, Bastar, Chanda.

A medium-sized grass growing in marshes and tanks with decumbent and swollen stems rooting at nodes, marked out from the above species by a ligule of fringe of hairs.

Perennial. Flrs. January–April. A good fodder ; grain eaten in times of scarcity.

XXXI. ELEUSINE Gaertner

Spikes digitate or umbellate ; lower glumes persistent, rachis inarticulate and terminated by a spkt. Spkts. awnless, biseriate.

88. *Eleusine indica* Gaertn. ; *Pandur, Pandhar* (Hindi). Mandla, Chanda, Bastar.

A very fibrous grass growing in wasteland, bunds of fields and garden compounds. Spikes umbellate or whorled, 3 to 20. Spikts. biseriate.

Perennial ; an ordinary fodder. It is very fibrous and the cows do not find it very easy to nibble it. Liked by buffaloes. It has very firm root and thus it gets hold on all overgrazed lands, roadsides, etc.

One specimen has been collected with one and much broader spike from a very rocky and dry locality.

89. *Eleusine coracana* Gaertn. *Madia* (Halbi), *Gorang* (Madia). Chanda, Mandla, Bastar.

A much taller and stouter plant than the above. Spikes shorter. Cultivated for its grain.

XXXII. ELYTROPHORUS Beau.

90. *Elytrophorus spicatus* A. camus *Gadel-tokar* (Madia). Mandla, Chanda, Bastar.

A small, tufted grass from 6″ to 18″ high ; panicle spiciform lobed, and flowering even to the base.

Annual ; grows in marshy places like small ditches, paddy fields, etc. Flrs. November–January.

XXXIII. ERAGROSTIS Beau.

Infl. of terminal, open or contracted panicles, rarely of simple spikes. Spkts. many, biserially and tightly arranged. Compressed, on continuous or articulate rhachilla. Never awned.

I. Spikes panicled.

A. Rhachilla breaking up from apex downwards.

a. Paleas long ciliate—*ciliata, coarctata, diplachnoides viscosa, japonica, plumosa.*

b. Rhachilla tough ; glumes falling off from the base upwards.

c. *uniloides, gangetica, nutans, diarrhena, ciliansis, tremula, poaeoides, pilosa.*

II. Spikelets secund on a simple spike with a slender rachis—*bifaria, nardoides.*

Most of the spp. are useless as fodder.

92. *E. bifaria* Wight ex-Steud (from Graham's book).

A small stiff grass up to 2′ high, leaves mostly at base convolute, upper surface puberulous, glumes not awned. Spkts. much laterally compressed.

Perennial ; semixerophytic, growing on gravelly, rocky and hard laterite soils. Flrs. September–October.

97. *E. cilianensis* (All) Link ex Lut. Mandla, Chanda, Bastar.

A small grass, culms decumbent, up to 8″ high ; panicle pyramidal with large slaty blue spkts. on short pedicles.

Annual ; a fair fodder ; common on black cotton soil specially in *Juar* fields. Flrs. September–November.

95. *E. ciliata* Nees. Mandla, Chanda, Bastar.

A tufted, medium-sized decumbent, stiff grass up to 2′ high ; peduncle of spike comparatively longer. Panicle spiciform, up to 2·5″ long. Glumes and paleas ciliate.

Perennial ; grows on alluvial soil and is generally found along rivers in open and under medium shade. Not a good fodder. Flrs. November–December.

96. *Eragrostis coarctata* Stapf. Bastar and Mandla.

An ascending, small, tufted grass with spicate or very close racemes ; glume obtuse, spike generally interrupted at base ; spike generally pinkish in colour.

Perennial ; it has a very firm root system and stands well in pastures, along foot-paths and roadsides. Flrs. August–October.

98. *E. diarrhena* Steud.

A very variable grass with paleas and glumes nearly smooth. There are many ecological varieties which, though identified as the same species appear very different in the field (Sheet No. 98 i). *Kamarksa* (Hindi).

A stout grass up to 2′ high, panicle dense and its branches mostly alternate ; mostly found in *Juar* and *Kutki* fields. Flrs. October–November. (Sheet No. 98 ii) a less stouter grass than the above. Panicle up to 9″ long much interrupted. Collected from wasteland in semi-marshy area, spikelets greenish.

(iii). Var. *Koenigii* Fischer ; *Phulsari* (Halbi), *Ghadela* (Hindi).

Panicle long narrow with short dense subereato-patent pseudo whorls. Spkts. purplish to pinkish. On sandy to sandy-loam soil (Sheet No. 98 vi).

Var. *Koenigii* Fischer.

A small stiff grass up to 12″ in height, leaves very small ; roots as large as the plant, very bushy and ramified ; branches of panicle in pseudo whorls. Spkts. green grey in colour.

Collected at Manot along the river Nerbudda from marshy places (Sheet No. 98 vii).

Var. *Koenigii*, Fischer.

A much smaller but stiffer grass up to 10″ high ; branches of panicles mostly alternate ; spkts. light pink in colour. Collected from bunds of paddy fields in Raipur.

91 (i) *E. diplachnoides* Steud. Chanda, Mandla.

A medium-sized to tall grass up to 4′ high with a large, lax, thyrsoid panicle up to 2′ long with whorled or alternate branches.

Annual ; growing in ditches and roadside, burrowpits. Flrs. September–October.

104 (i) *E. gangetica* Steud. ; *Tiya-buta* (Halbi), *Horang* (Madia). Chanda, Mandla, Bastar.

A medium-sized, weak grass up to 3′ in height ; spkts. closely set on long branches of panicle, pointing forward, grey green in colour.

Perennial ; common along *nallas* and in sal forest blanks ; in Chanda, collected from Mukri Forest Rest-house compound ; fair fodder. Flrs. September–October.

91 (ii) and 98 (iv and v). *E. japonica* Trin. Chanda, Mandla, Bastar.

Paleas and glumes nearly smooth. A very variable grass growing in *Juar* fields in Chanda, muddy pools and burrow-pits. Pseudo whorls very much ramified and sometimes divaricate. Flrs. September–October.

100. *E. nordoides* Trin. Not collected. (Distribution taken from Graham's book).

A slender, densely tufted grass up to 20″ high ; leaves erect filiform, 6–9″ long with many long, scattered or grouped hairs which project from the involute margins. Spike long slender ; spikelets closeset erectopatent and wide at base.

99 (i). *E. nutans* Nees. ; *Tiya-buta* (Halbi). Mandla, Bastar, Chanda.

Stem slender, up to 18″ high, panicle ovate or oblong, branches capillary, rachis very zig-zag. Spkts. fascicled and crowded at the end of the panicle branches.

Perennial ; good fodder. Flrs. April–October.

101. *E. pilosa* Beauv. Common.

A very slender, weak grass up to 12″ high ; panicle very lax, delicate, feathery, open or contracted with capillary branches and slender spkts. ; light brown to white or purple in colour ; branches of panicle in pseudo whorls.

Annual ; on sandy, murram and gravelly soil ; in compounds, along roadsides, on old walls and on old tiled roofs. Flrs. August–September.

102 and 103. *E. plumosa* Link. Bastar, Chanda, Mandla. Common.

A small, weak grass up to 18″ high ; panicle very effuse with capillary branches. Mouth of sheaths and nodes of panicle bearded.

Perennial ; mostly on sandy soil under medium or side shade. A good fodder grass.

99 (ii) *E. poaeoides* Beau. ; *Tiya-buta* (Halbi).

In forest blanks of Mandla and bastar. In Chanda, collected from Mukri rest-house compound.

Very similar to *E. nutans* except that the branches are lax and the spkts. are not crowded.

Perennial. Flrs. April–October.

105. *E. tremula* Hochst. ex Steud. Chanda, Mandla, Bastar.

A very pretty grass with very effuse panicle ; spkts. long narrow, up to 1″ long, light pink, distant, on long capillary pedicels ; with little breeze they tremor.

Annual ; leaves very small and thus the plant is hardly valuable as fodder. Flrs. September–October.

106. *E. unioloides* Nees. Common.

A small grass, up to 12″ high, with beautiful, broad ovate pinkish spkts. ; glumes very closely set.

Perennial ; growing on low land, along shallow ditches and water-logged areas. Not good fodder. Flrs. August–November.

107. *E. viscosa* Trin. Common.

A small decumbent grass up to 1′ high, very similar to *E. riparia*. Spkts. villous and give off the odour of turpentine.

Perennial ; in grasslands and wastelands on sandy-loam soil. Flrs. September–November.

XXXIV. ERAGROSTIELLA

93. *E. brachyphylla* Bor. Chanda, Mandla.

A medium-sized grass, up to 2′ high, with leaves mostly at base ; leaves not puberulous on the surface ; spkts. terete, often twisted and appear uniseriate ; spike generally curved.

Perennial ; semi-xerophytic on lateritic and poor soils, in the open forest. Flrs. September–October.

94. *E. tenuifolia* Hochst. ; *Godawari* (Hindi). Betul, Mandla, Bastar (above 1500′ ele.).

A tall, robust grass up to 3′ high ; panicle grey open. Marked out by the persistent paleas.

Perennial ; not liked by cattle and seen flourishing in wastelands and along roadsides. Flrs. November–January.

XXXV. EREMOPOGON

7. *E. foveolatus* Stapf. ; *China marvel.* Chanda, Mandla and Bastar.

A medium-sized grass 1′ to 2½′ high, grey green in colour. Basal sheaths woolly, with white hairs. Glumes pitted, purplish in colour.

Perennial ; common on lateritic and gravelly soils in *maidans*. Rare in Bastar. A good fodder both in green and dry state. Flrs. October–November.

XXXVI. ERIOCHLOA, H. B. AND K.

111. *E. procera* Hubb. Mandla, Bastar, Chanda.

A slender grass up to 30″ in height ; spkts. laterally compressed ; glumes minutely silky ; joints of the pedicels marked by a reddish knob, glume (i) absent.

Perennial ; found in paddy fields, burrow-pits, along banks of rivers, etc. A good fodder grass. Flrs. August–October.

XXXVII. EULALIA Kunth.

Spkts. in digitate spikes ; rachis articulate ; glume (ii) of lower spkts. not awned.

112. *E. phaeothix* O. Ktz. Bastar (1500′).

A grass of higher elevations ; rootstock densely brown, woolly ; spkts. and pedicels covered with golden brown hairs.

Perennial ; a common grass in sal forest of Bastar, easily marked out by the dense, woolly basal sheaths exposed after the summer fires. Not good fodder. Flrs. October–December.

113. *E. tristachya* O. Ktz. ; *Mothi-marbel*, *Gunti* (Hindi), *Repa-nonda* (Madia).

A tall, tough grass with digitate spikes 4″–6″ long and covered with white hairs.

Perennial ; grows in open hilly forests. Flrs. October–December.

A much commoner variety which is much smaller in shape and size except for the length of the spkts. is found in open sal forest and forest blanks of Mandla and Bastar divisions generally gregarious. Flrs. October–November.

(*to be continued*).

STUDIES ON THE SPIKE DISEASE OF SANDAL *SANTALUM ALBUM* LINN.

BY M. J. NARASIMHAN
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SUMMARY

Earlier investigators on spike disease of Sandal formulated theories regarding the cause of the disease, such as "unbalanced circulation of sap", and deleterious effect of the host plants on sandal, etc., without adducing sufficient or any experimental data.

The infectious nature of the disease was established by us for the first time, by reproducing the spike symptoms on a healthy plant by grafting a small spiked twig on it.

Haustorial connections between spiked trees and healthy trees were carefully traced out to infer the possibility of the underground transmission of the disease through the roots.

Many methods of sap inoculation to transmit the disease were tried, but were not successful. Some promising methods are yet to be tried.

Cytological investigations, carried out in great detail, revealed that in the diseased tissue intracellular inclusions adpressed to the nuclei, were regularly present. These inclusions are characteristic features of some of the plant and animal virus diseases, worked out by other investigators. An article entitled "Cytological investigations on spike disease of sandal" was published by me in Phytopathology.

A study of the earlier contributions to our knowledge of spike disease of sandal reveals many facts based on careful field observations and quite many vague theories about the cause and spread of the disease not based, however, on accurate experiments. Instances of this kind may be mentioned, as in the case of the "Unbalanced circulation of sap", and the theories on the deleterious effect of some host plants on sandal. It was obvious at the outset that the disease spreads in a sandal plantation like wildfire, but the reasons attributed for it, viz., some poison secreted by some deleterious host plant of sandal, where not put to the test or proved by experiments. Almost the first definite work done by me under the guidance of Dr. L. C. Coleman, was to trace the haustorial connection between a fully spiked tree and a sandal tree apparently all healthy except for one small branch breaking out into spike. It was a justifiable inference, though not a definite proof, that the disease may have been transmitted from the spiked tree, to the healthy tree twenty yards off, through the haustorial connections. A more definite evidence that the disease can be transmitted from one sandal tree to another, was found when the disease was transmitted to a healthy tree by grafting diseased scion. A two-inch spiked twig grafted on a small tree 8 feet high, incited diseased symptoms all over the healthy tree in six months. From this definite find that the disease was infectious, further work was taken up to see if the sap of the spiked tree was infectious. The following methods were tried :—

(1) Rubbing of the sap, obtained by grinding spiked leaves, on healthy leaves of potted sandal (as done in the case of transmission of tobacco mosaic). (2) Pricking healthy leaves with a bundle of fine entomological pins, through a layer of spiked leaves super-posed on the healthy leaf. (3) Making a healthy tree take up diseased sap, contained in a wax cup, moulded around the base of the stem. (4) Sap injected into a healthy tree (about 300 cc.) by means of an injection apparatus. It showed that

diseased sap, in quantity, either trace or large, was not infectious. The above experiments showed that the spike disease of sandal is akin to Peach yellows, Potato leaf roll, etc., wherein the disease is transmitted only by grafting and not by sap inoculation. Two promising methods of inoculation, which were not fully pursued to proof, however, were :—(*a*) Burying infectious material incorporated into plaster of paris, round the roots of healthy sandal plants, with a view to see whether infection will be taken up, through the haustoria formed on the plaster of paris sticks. (*b*) Training *Cassytha* plants (a phanerogamous parasite belonging to N. O. Lauraceae), grown on spiked sandal, on to healthy plants enclosed in a cage, with a view to see whether the infection is transmitted through the haustoria of *Cassytha*. This work similar to that done in the case of other virus diseases, using *Cuscuta*, another flowering parasite, as the transmitter, was somewhat promising, but needs confirmation. The Entomologist, Mysore Agriculture Department made an insect survey of the spiked area near Closepet (Chikmangudde Forest), and a mass collection of the insects feeding or occurring on spiked trees. The insect selected or suspected out of the lot, failed to transmit the disease. From all the above investigation it was preliminarily concluded that we are dealing with a virus disease, though the results obtained, except for successful graft-transmissions, did not warrant such a conclusion, since it was not proved that the infection could be transmitted by sap or through insects. Indeed, many diseases in the world classed under "Virus" have not answered all the tests by which virus diseases should be identified. The next line of tackling the problem was by means of cytological investigations. Based on the study of innumerable microtom sections of both healthy and diseased tissue, the following observations were reported : (1) The starch content of the pith and the medullary rays of the stem and the petiole was prominently abundant. The starch grains were large sized. (2) The starch grains manufactured in the chloroplasts of the leaf were minute and abundant, as compared to that in the healthy leaf. (3) The necrotic areas in the phloem were marked with the sieve-tubes collapsed, similar to that observed in leaf roll of potatoes. (4) A definite alteration of the cell structure of spiked leaf as compared with that of the healthy, was found. Apart from the alterations described in (2), the degeneration of the chloroplasts, especially in advanced stages of spike, was quite marked. Adpressed to the nucleus, was to be found, in almost every cell, a round or sometimes irregular shaped body vacuolated in structure. This cell-inclusion is exactly similar to that found in tobacco mosaic, and certain other virus diseases. This discovery in sandal spike places this disease definitely beyond doubt in the class of virus diseases. Staining technique followed in the case of fowl-pox and rabies was also tried with the result that the inclusions in spiked sandal reacted in the same way.

TERMINALIA ARJUNA, BEDD.

BY K. KADAMBI

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(Syn. *T. glabra*, W. et, Arn., *Pentaptera arjuna*, Roxb., *T. crenulata*, Roth.).

Local names—Hindi—*Anjan, arjun, arjuna, anjani, arjan, jamla, koha, kava, kahuva* ; Uriya—*Arjuno, orjuno, panda, sahajo* ; Cuttack—*Hanjal* ; Santhal—*Kowha* ; Kol—*Gara-patana, gara-hatna* ; Khond—*Mardi* ; Tamil—*Vella-marda, attumaruthe, vella-matti, tanikai, marudai, vella-maruthn* ; Marathi—*Arjun, anjan, sadura, savimadat* ; Kannada—*Maddi, tore-matti, bili-mathi, nir-matti, bolu-matti, hole-matti* ; Telugu—*Yermaddi, yerramaddi, tella-madu, thella-maddi* ; Gondi—*Mangi, koha* ; Hyderabad—*Kohua, vag-maddi, harrad-maddi* ; Malaya-lam—*Vellu-marnthu* ; Burma—*Tankkyan* ; Cinghalese—*Kumbuk.*

Arjuna, which is the name of the tree in Sanskrit, is said to be named after *Arjuna* the hero of the *Mahabharata.*

Description—A large handsome tree, evergreen or nearly so, attaining a girth of 10 feet and a height of 60 to 80 feet and over. The stem is rarely long or straight, but generally always buttressed and often fluted ; branches drooping. Bark pinkish grey, smooth, exfoliating in irregular sheets, green when freshly exposed, turning light grey, pink inside. The young bark has chlorophyll. In favourable localities and especially along the banks of streams, the tree attains very large sizes. Two trees of 26 feet and 32 feet in girth at 5 feet from the ground have been recorded in the village of Manapur in Jammu, Kashmir. (*Ind. For.*, Vol. 29, p. 152). The writer measured a tree nearly 102 feet high and over 16 feet in girth close to the bank of the Cauvery near Sivasamudram falls in Mysore.

This beautiful tree is recognized at once by its smooth, exfoliating bark, mode of growth and its habitat. It is distinguished from *T. tomentosa* by the smoothness of its bark, by its fruit being more angled than winged, by the narrower leaves and by its prefering the banks of streams. As it is normally confined to such localities it is not of much forest importance, but is a fine avenue tree and is consequently perhaps even more planted than *T. tomentosa.*

Leaves sub-opposite, oblong or elliptic or only glabrous beneath, hard, coriaceous, usually 4 to 6 inches (occasionally 10 inches) long, cordate, shortly acute or obtuse at the apex. Petiole rarely more than ½ inch with two glands near the apex.

Flowers in usually panicled spikes, bracteoles very small, calyx teeth nearly glabrous, young ovary very short, covered with crisped brown or rufous hair. *Fruits* 1 to 2 inches long, nearly glabrous, ovoid or ovoid-oblong, with 5 to 7 wings, not very wide, their striations curving much upwards, suddenly narrowed at the top. (Thick, narrow wings, irregularly marked with ascending lines : Brandis).

Hooker (Fl. Br. I., Vol. II, p. 447) mentions of a variety which he calls var. *angustifolia* found in the Southern Peninsula and Konkan which has narrow, elongate, oblong leaf-blades which suddenly narrow into the petiole.

Locality and habit—The tree is generally found along forest streams, ravines, dry water courses and river banks, from Oudh, where it is not frequent, southwards through Bihar, Orissa, Madhya Bharat, Vindhya Pradesh, Madhya Pradesh, Gujrat, Northern Circars, and Deccan down to the extreme tip of the peninsula and across the sea to Ceylon. It is rare in the Carnatic but fairly plentiful in Tirunelveli and on the west coast (Fig. 2). It is extensively

planted in India for shade or ornament, in avenues or parks, even in very dry and hot localities. It is found in West Bengal but not in Burma.

Associate tree species—As already stated the tree inhabits the borders of streams which are generally perennial, this being its most characteristic habit at. In Balaghat forest division, Madhya Pradesh, among the common trees found in the mixed forests, where *T. arjuna* is found along *nala* banks are : *Terminalia tomentosa, Anogeissus latifolia, Lagerstroemia parviflora, Pterocarpus marsupium, Bombax malabaricum, Terminalia belerica, Diospyros melanoxylon, Terminalia chebula, Schleichera oleosa, Soymida febrifuga, Schrebera swietenioides* and others. (W.P. for the Baihar and Supkhar ranges, Balaghat division, Eastern Circle, Central Provinces, 1932–42, by Gurdial Singh, B.sc., Nagpur, 1932, p. 6).

In the Kangra valley, at the lower altitudes of Haimpur, Nurpur and Kangra, *Terminalia arjuna* occurs along with other trees of medicinal importance like *Acacia catechu, Cassia fistula, Phyllanthus emblica, Terminalia belerica* and others. (K. S. Ahluwalia, Medicinal plants of Kangra valley ; *Ind. For.*, April, 1952, p. 188).

Climate—In the natural habitat of *Terminalia arjuna*, the absolute maximum shade temperature varies from 110° to 118°F., the absolute minimum from 30° to 60°F., and the normal rainfall from 30 to 70 inches or more. But, owing to its localized habitat chiefly along stream banks its distribution is not governed only by climatic factors.

Leaf-shedding, flowering and fruiting—The tree is nearly evergreen; the new leaves appear at the beginning of the hot season. The spikes of small white flowers appear from April to July, earlier in the Deccan than in the plains of Northern India. Every third-year is a good seed year. (Paper read at the Tannin Conference, 1917, on the Silviculture of Tan yielding species). The fruits ripen in the following February to May. In Ceylon C. H. Holmes says that the tree flowers in April/May and the fruits ripen from September to November. They have a hard bony axis and 5 to 7 wings from $\frac{1}{4}$ to $\frac{1}{2}$ inch wide. The weight of the fruit has been variously recorded :—Troup has given it as 80 to 110 per lb., but Sen Gupta gives 80 fruits per lb. of fruits collected from December to February, and 170 per lb. of those collected during April–May. Madhya Pradesh fruit weighs 210 to the lb. (K. P. Sagreiya : seed weights, plant per cent, etc., collected in Betul division, C.P. and Berar, 1938). The tree flowers and fruits at an early age. Marsden has recorded that a tree in the F.R.I. compound, Chandbagh, Dehra Dun, planted in 1914, was in full fruit in October 1918.

Germination and seedling—Germination epigeous ; the endocarp opens lightly and the radicle emerges. The hypocotyl elongates by arching and the large leafly cotyledons unroll. The hypocotyl then straightens out and lifts the cotyledons above ground, and meanwhile the young shoot emerges from between the two cotyledons.

The primary root is long, tapering and wiry. The lateral roots are numerous, fibrous and distributed down the main root. The hypocotyl is 2·2 to 3 inches long and tomentose. The cotyledons are petioled, with a lamina 0·7 to 0·9 inch by 1·4 to 2·2 inches, leafy, reniform, much broader than long, with three conspicuous and two minor veins rising from the base. *Stem* erect, terete, pubescent. *Leaves* simple, alternate, or first pair sub-opposite, ex-stipulate. Lamina 2·4–4 inches long, elliptic lanceolate, apex and base acute, widely serrulate, lateral veins 8–12 pairs.

The seedlings of this tree are differentiated from those of *T. tomentosa* and *T. chebula* by the length of the hypocotyl and by their petioled cotyledons. A fairly long tap-root is developed which may attain a length of 2 feet within a couple of months of germination. During the first few years of its life the plant generally assumes a straggling habit, forming long side branches which bend over towards the ground. Artificially tended plants may not assume this straggling form ; for example, plants raised in Dehra Dun attained a height of 6 to 10

feet in 3 years ; so also, plants raised in Berar attained a height of 1½ feet in 2 years and at Nagpur 3 feet in 2½ years.

Silvicultural characters—The tree is a moderate shade bearer ; it does not tolerate dense overhead shade. It has a more or less superficial root system which spreads radially on the bank of streams which form its favourite habitat. The tree prefers loose, moist, fertile, alluvial loam. The seedlings are sensitive to frost and drought and grow well in full sunlight provided the ground is adequately moist. C. M. Mc. Crie (*Ind. For.*, 1900, p. 338) states that in the abnormal drought of 1899–1900 many trees along the banks of streams in Nagpur district died owing to the lowering of the sub-soil moisture level. The species is not suitable for planting on open, dry hill-sides (report on the artificial regeneration works in Saharanpur, 1925–26). Young natural seedlings in forests die back for 6 to 7 years developing a bushy habit, during which period their root system grows stronger ; then a strong leading shoot may be expected to develop. The tree pollards very well and also produces root suckers. Its coppicing power is satisfactory up to a girth of 2½ feet, after which it is indifferent (Troup). In an experiment done in Bombay State, 47 per cent of the trees felled yielded coppice shoots though trees over 30 inches girth did not coppice satisfactorily. Coppice shoots 12 feet high and 10 inches in girth can be expected in 6 to 7 years.

B. L. T. De Silva. has stated that the tree can remove calcium from the lower layers of the soil and store it in its tissues. The surface layer of soil beneath the tree are left richer in calcium than those outside its range owing to the liberation of calcium from the decomposing leaves. (Biological Abstracts, Vol. 9, No. 6, June–July 1935, p. 1235).

Parker has mentioned of a probable hybrid variety between *Terminalia tomentosa* and *T. arjuna* going under the names *arjun* and *arjun-sadada* in East Khandesh and North Khandesh respectively and having the characters of both *T. tomentosa* and *T. arjuna*. Some seeds of a couple of these hybrid trees from Khandesh were sown in Dehra Dun. It was found that during the germination process the method of unfolding of the cotyledons showed every stage of transition between the typical *T. tomentosa* and *T. arjuna*. The majority of the seedlings approximated more to *T. tomentosa* than to *T. arjuna*. (*Ind. For.*, Dec. 1925, pp. 601–2).

Natural reproduction—This is fairly satisfactory. Dense natural reproduction is often found in forests where the seed has accumulated alongside stream banks by the flow of water. Under forest conditions germination commences early in the rainy season, during the pre-monsoon rains. It takes place easily when the seeds get buried on the banks of streams where there is a considerable amount of soil moisture or under artificial conditions if the soil is kept continuously moist by percolation thus simulating the natural conditions found along forest streams. The seed does not germinate readily if exposed to the sun, and the radicle is liable to dry up under such circumstances. E. Marsden says that plants put out on the bank of streams 1 or 2 feet above the level of water in the stream have thriven well. Though heavy shade is injurious moderate shade, especially side shade, is advantageous.

Artificial regeneration—The tree has been successfully planted alongside the canals of Uttar Pradesh. It has also been raised satisfactorily as a roadside tree in various parts of India.

The seeds ripen from February to May. About 22 seeds weigh 1 oz. (Silv. Res. Rpt., Madras, Part II, 1938–39, pp. 131–33). Germinative capacity varies ; it is generally about 50 to 60 per cent. The germinative capacity has been given as 62 per cent by Sen Gupta (I.F.R., Vol. II, No. 5, 1937), but in Dehra Dun, a maximum of 78 per cent has been obtained in some instances. The seeds are fit for collection during April–May. Germination starts in about 20 days and is complete in about 7 to 8 weeks. In Betul division, Madhya Pradesh, Sagreiya has found the period of commencement and completion of germination to range

FIG. 1.

Natural growth of *Terminalia arjuna*, in a typical site along river bank, Hoshangabad division, Madhya Pradesh.

Photo : M. V. Laurie.

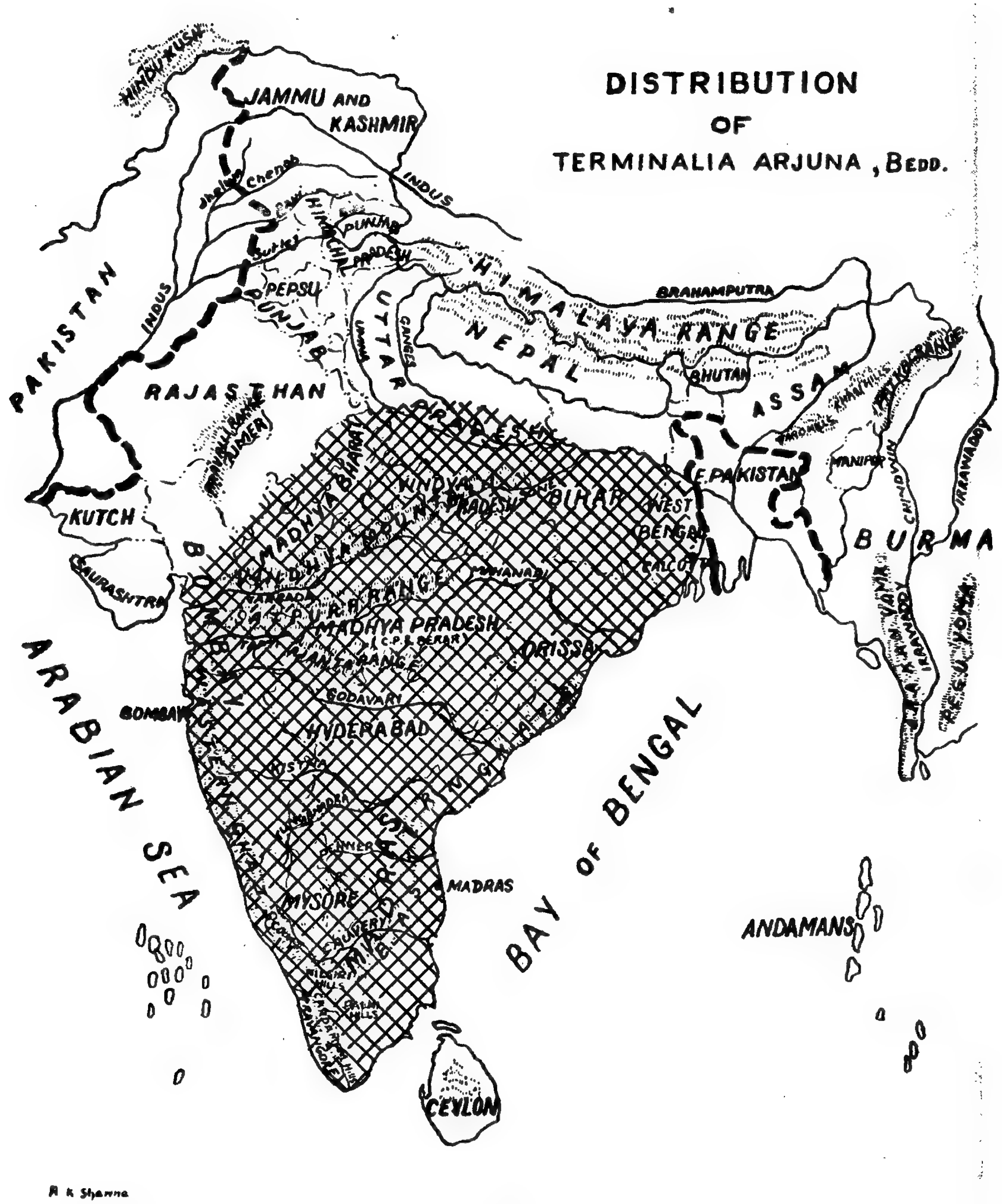
DISTRIBUTION
OF
TERMINALIA ARJUNA, Bedd.
HINDU KUSH
JAMMU AND
KASHMIR
INDUS
PAKISTAN
PEPSU
PUNJAB
RAJASTHAN
UTTAR
HIMALAYA RANGE
NEPAL
BRAHAMPUTRA
BHUTAN
ASSAM
E.PAKISTAN
MANIPUR
BIHAR
WEST
BENGAL
BURMA
KUTCH
SAURASHTRA
MADHYA PRADESH
(C.P. & BERAR)
ORISSA
GODAVARY
BOMBAY
HYDERABAD
ARABIAN SEA
BAY OF BENGAL
MYSORE
MADRAS
ANDAMANS
CEYLON
IRRAWADDY
CHINDWIN
R. K. Sharma

FIG. 2.

from 17 to 53 days. (Sagreiya, K. P., Seed weights and plant per cent, etc., in Betul division, Madhya Pradesh, 1938).

The tree can be raised successfully by means of stumps, or entire transplants and also by sowing seeds. Experiments done at Dehra Dun indicate that the best size of stumps to use varies from 0·5 to 1·0 inch in diameter. Under Dehra Dun conditions the best time for stump planting the species is at the end of July ; seedlings bear transplanting well during the first rains before the tap-root becomes too long. Nursery seedlings $2\frac{1}{2}$ months old whose average length of root and shoot was 12 inches and 5 inches respectively, planted after removing all except the top pair of leaves, showed a survival of 58 per cent and a height growth of 38·9 inches after 3 years. The condition of the surviving plants was fairly satisfactory. Direct sowing is also successful. In Dehra Dun, germination commences in about 3 weeks and the early growth of plants, under nursery conditions, is rapid ; in one case they attained 10 inches and 17 inches heights in 2 and 3 months, respectively. The species can also be successfully raised along with field crops. In Dehra Dun an experiment in raising this species with a *mandwa* (*Eleusine coracana*) crop along cleaned strips 3 feet and 4 feet wide resulted in plants which were 6 to 10 inches high in the 3 feet wide strips, and 9 inches to 16 inches high in the 4 feet wide strips, when the *mandwa* crop was harvested, by which time the tree seedlings were only 3 months old. The tree was introduced by sowing its seed. The tree cannot be propagated by using branch cuttings.

Irrigated line sowings have also proved successful, but if the soil is well loosened irrigation can probably be dispensed with. Under Dehra Dun conditions direct line sowings in loose soil have done well without irrigation. Young seedlings suffer from drip and frost, some plants being killed outright by the latter. Weeding during the rains is a useful measure against frost. If sowing is deferred to late June, watering is unnecessary but to raise transplants sowing should be done in April–May and watering has to be done. E. Marsden says that plants sown direct appear to stand the hot weather better than transplants. (E. Marsden's ledgered notes).

External dangers and protection—The effect of drip and frost on nursery plants at Dehra Dun has already been referred to. In one experiment, entire transplants planted in pits 12 by 6 inches in size and made 2 feet apart in lines spaced 4 feet apart from one another and weeded were tall enough to escape damage from frost at the end of 4 years, but the results need confirmation. In Lahore (West Pakistan) *Terminalia arjuna* which is an exotic is frosted back almost every year. A destructive leaf spot caused by a fungus has been reported on the leaves of this tree by A. E. Jenkins. The organisms *Phomopsis* sp. and *Pestalotia disseminata* have been isolated in this connection. (Biological Abstracts, Vol. 17, No. 7, 1943, p. 1776).

Statistical—Few reliable statistics are available regarding the rate of growth of *Terminalia arjuna*, but the rate of early growth of seedlings and saplings properly weeded and looked after, has been found to be fast. The following details of early growth of nursery plants are available :—

Terminalia arjuna.—Rate of growth of seedlings under nursery treatment

(1) Sown 27th June 1917

	inches	Remarks
Height on 26–9–17 up to	10	
,, ,, 15–10–17 ,,	17	
,, ,, 16–1–18 ,,	18	Frost damaged.
,, ,, 21–9–18 ,,	45	
,, ,, 2–1–21 ,,	60	

(2) Sown on 22 June 1917

	inches	Remarks
Height on 25–9–17 up to	9	
,, ,, 19–10–17 ,,	13	
,, ,, 18–1–18 ,,	15	
,, ,, 14–8–18 ,,	42	

(3) Sown on 21st June 1917

Height on 3–8–17 up to	5	Irrigated line sowings.
,, ,, 15–10–17 ,,	18	
,, ,, 18–1–18 ,,	20	

(4) Sown on 5th August 1917

Height on 5–8–17 up to	5	Sown along with a field crop of *mandwa*.
,, ,, 24–9–17 ,,	8	
,, ,, 16–10–17 ,,	8	
,, ,, 23–9–18 ,,	32	

(5) Sown on 22nd June 1917

Height on 5–8–17 up to	5½
,, ,, 16–10–17 ,,	16
,, ,, 23–9–18 ,,	25
,, ,, 17–3–20 ,,	49

(6) Sown on 24th June 1917

		inches	Remarks
Height of majority of plants on	31–7–18	from 13 to 19	Unirrigated line sowings.
,, ,, ,,	3–10–18	,, 30 to 53	
,, ,, ,,	30–3–20	,, 41 to 79	

Nursery stock about 2½ months old planted out at Dehra Dun in the open with naked roots attained an average height of 7·3 inches, 10·1 inches, 24·5 inches and 38·9 inches at the end of 1, 2, 3 and 4 years respectively.

Troup has mentioned of a cross section from a stem which is 2 feet 8½ inches in girth over bark as containing 43 rings and giving a mean annual girth increments of 0·75 inch. Three trees raised from seed sown in 1901 at Chaibassa, Chota Nagpur, attained the following dimensions in 16 years :—

(1) Height 40 feet, girth 2 feet 11 inches
(2) ,, 37 ,, ,, 2 ,, 8 ,,
(3) ,, 37 ,, ,, 1 ,, 8½ ,,

(Troup, R. S., Silv. of Ind. Trees, Vol. II, p. 532).

The exploitable girth of the tree has been fixed by J. Carr at 5 feet in the High Forest Working Circle of the old Working plan of Balaghat division, Madhya Pradesh (J. Carr, Working Plan Report for Balaghat division, 1914–15 to 1943–44).

UTILIZATION

Timber—Moderate quantities of this timber are available from most localities in Chota Nagpur, Madhya Pradesh, Tirunelvely, Deccan and the west coast. The average quantity

which could be got from each area has been estimated at 20 to 50 tons. As the tree is mostly found along the banks of streams it has generally got to be spared from the axe for protection purposes.

General properties of the Wood—Sapwood is reddish-white; heartwood is brown to dark brown and streaked with darker, blackish lines. The wood has a lustrous hue, with no characteristic taste or smell. It works to a fairly smooth surface, and is more or less irregular and interlock grained and coarse textured. It is moderately heavy, its specific gravity being 0·74.

Mechanical properties—The timber is hard and strong like that of *T. tomentosa*. Weight 48 to 54 lbs. (Gamble, p. 341), 47 lbs. at 12% moisture (Pearson and Brown). The following table gives the results of the tests made :—

Moisture percentage of oven-dry wood	Weight in lbs. per c. ft. at 12·2% moisture	Transverse strength in lbs. per sq. in.	
		Breaking strength	Young's modulus
12·2	51	10,820	1,511,000

Crushing strength parallel to grain in lbs. per sq. in. .. 6,140 (Pearson and Brown, p. 517–518).

The timber is thus slightly stronger in transverse strength than Burma teak, but approximately 26 per cent below teak in withstanding stress parallel to the grain.

Seasoning properties—The timber is difficult to season, liable to split, and not also easy to work, resembling *T. tomentosa* in this respect. It is not safe to fell the tree at the beginning of hot weather as it splits, nor is it desirable to leave the log in the forest as insects attack especially its sapwood. Fair to good results are reported from green conversion. It would be good to fell the tree early in the cold weather and then season it. In South Chanda, Madhya Pradesh, fair to good results were obtained by girdling the tree and letting it season for 2 years.

Durability—The sapwood is very liable to insect attack but the heartwood is durable under cover and is said to last for fifteen years. The heartwood is not easy to treat and takes about 4·5 lbs. of the preservative per c. ft. The heartwood is fairly resistant to white ants but not immune to it (H. Trotter).

Working qualities—The timber takes a lasting and fine finish. It is distinctly ornamental, and has to be carefully selected in order to obtain satisfactory results.

Uses, present and prospective—The timber is used for house-building (Deccan), solid cart wheels (Chota Nagpur) shafts, axles, naves of wheels, agricultural implements, well-kerbs, boat-building, oars, masts, water-troughs (Cuttack) and mine props in the Kolar Gold mines of Mysore. It deserves more trials for furniture and cabinet work after careful seasoning and selection. It has been pronounced to be suitable for second class plywood used in making tea chests.

Minor Forest Products—The bark of *T. arjuna* is valuable as a tanning agent for sole-leather, especially the bark on the bole of the tree which contains 20 to 24 per cent of tannins as compared with the bark of branches which carries 15 to 18 per cent. Once removed the new bark grows thick again within two rains. The leaves have no tannin in them. For collection

purposes the bark is best chopped off and not peeled ; when this is done, a 3-year rotation is indicated (E. Marsden). In Madhya Pradesh what is called a "Fraymouth cutter" was devised several years ago for removing the bark ; this instrument enters, cuts and chips out a small quantity of the bark without injuring the cambium. It is almost impossible to cut into the Cambium with this instrument, and it is possible to strip the whole of the bark of the bole in October–November removing ½ to ¾ inch thickness of the outside layers of the bark all round the tree. By the following spring the top-layer of the bark dries up and flakes off leaving the tree completely healed. Within two years the bark will again grow to its original thickness. The chipped bark affords a rich tanstuff suitable for heavier and denser leathers. The tannin principle found in the bark of this tree behaves towards reagents in the same way as the English Oak bark, that is to say it gives some of the reactions for pyrogallol and some for catechol tannins. With this bark the leather becomes light brown with no excessive red tint and the grain is left in a smooth condition – (Indian Tanstuffs and their Tannage, Bulletin No. 1, 1918, by *W. A. Fraymouth* and *J. A. Pilgrim*, L.T.C.). Fraymouth has estimated that 20 to 100 lbs. of dry bark can be got per tree.

The tree gives a brown, transparent gum. The bark is also used as a tonic to heal wounds. The fruits of *Terminalia arjuna* and *T. belerica* are used in Indian medicine for heart ailment (*Ahluwalia, K. S., Ind. For.*, April 1952, p. 188).

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THE FOLIAR CONSTITUENTS IN SOME TREE SPECIES OF *SHOREA ROBUSTA* FORESTS OF THE SIWALIKS, U.P., INDIA

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Foliar analysis as a guide in plant nutrition, crop yield, soil fertility and fertilizer-treatment studies of soil is extensively employed in agricultural research in western countries (Burkhart, 1941 ; Chapman, 1941 ; Davies, 1940 ; Gilbert and Smith, 1929 ; Hester, 1941 ; McCollam, 1944 ; Moser, 1941, 1941*a* and Scarseth, 1941, 1943). Sometimes the analysis of the soil and subsoil are also undertaken in addition to the analysis of green plants. For a complete chemico-physiological test of the soil, Lundegardh (1934, 1938) suggested a triple analysis method in which the analysis of the plant, soil and the subsoil is done. According to Lundegardh "in some instances the ash analysis alone gives enough information ; in most instances ash analysis plus analysis of the surface layer of the soil will be sufficient ; and in still other instances ash analysis, analysis of the surface soil, and analysis of the subsoil are needed" (1938, p. 451).

In subsequent work it was found that the analysis of the surface soil and subsoil could be dispensed with, for the additional information provided by these tests was not of any greater value than that obtained by analysis of the plant alone. Extensive studies by "Mitchell (1939) and Lundegardh (1941) have shown that plant analysis makes full allowance for the extent to which plant roots penetrate different soil horizons, whereas this can hardly be done in a technique of soil analysis alone" (Goodall and Gregory, 1947, p. 116). Thus, the analysis of plant alone provides fairly complete information on the status of the soil and the requirements of plants. Recently an English edition of Lundegardh's book, "Die Blattanalyse" (Lundegardh and Mitchell, 1951) has appeared, which gives a complete summary of leaf analysis technique developed in agricultural studies.

The analysis of the soil by means of plants has been successfully done by Hall (1905), Gilbert and Smith (1929) and many others. Thomas (1934 ; 1937 ; 1938 ; 1938*a*) and Thomas and Mack (1940 ; 1941 ; 1943 ; 1944) in a series of papers have described in detail the technique, application, limitations and results of foliar diagnosis in agriculture and horticulture.

Wallace (1943) has developed methods for diagnozing mineral deficiencies in fruit trees by foliar analysis, and Chapman and Brown (1943) have further demonstrated the use of this method in estimating fertility needs of citrus. Drosdoff (1943) determined fertilizer needs of tung oil tree by foliar analysis.

Although, foliar analysis as a tool in soil fertility studies and other related topics is now well advanced in agriculture and horticulture, very little work is done in forestry problems. Extensive survey of the available litrature by Goodall and Gregory (1947) seem to suggest that foliar analysis as an ecological method in soil fertility, forest reproduction and plant distribution studies may lead to useful results, especially, when Mitchell's (1936) work on conifers has already shown that "much valuable information regarding tree nutrition and the chemical aspects of site quality can be obtained from leaf analysis" (Lundegardh and Mitchell, 1951). The importance of leaf analysis studies became apparent when foliar and surface soil studies in English forests provided to the author (Puri, 1950*a*) invaluable guidance in determining the successional trends in forest vegetation and conditions under which regeneration

of various species was found. The data for foliar ash, Ca, N, C and C/N of a few tree species from temperate and deciduous forests by Puri and Gupta (1950 ; 1951) provided additional information on soil conditions and indicated the type of forests in which forest regeneration was at its best.

Since most of our forest reproduction problems are capable of solution by changing soil and humus conditions and altering successional development of a plant community, it was considered probable that foliar analysis method may yield data of value in guiding regeneration techniques in some of the Indian forests. The present studies were, therefore, started in 1948, with this end in view.

The technique of leaf analysis is not fully developed for forest trees and before taking up detailed work on all types of Indian forests it was thought advisable to see if in a small area differences in foliar constituents are specific in nature and whether they show relationship with soil conditions.

These studies were, therefore, started in the nearest forests in the Dehra Dun Valley. A description of these forests and their succession has been presented by the author (Puri, 1950) and only foliar analysis data will be given here. Leaf specimens for analysis were collected in the months of October–November, 1948 from the reserved forests of Lachiwala, Kansrao, Thano and Asarori. However, five species were gathered from plantation in the New Forest during the months of September–October of the same year. Mature leaves were taken from middle-sized trees or shrubs, and one sample constituted leaves from 9–10 trees growing generally within a radius of 90–100 feet. In the plantations it was not possible to get leaves from many trees and one sample was drawn from only 2–3 trees in most cases.

Leaves were dried in the sun and powdered in a grinding mill, sieved and ashed on bunsen burners after determination of moisture content by keeping in an oven for 2 hours at temperature of 65°C. The ash was dissolved in N/4 HCl and CaO was determined by the usual oxalate method given by Loomis and Shull. Two replicates were taken and in one or two cases when difference between two determinations was more than 2 per cent a third replicate was also taken. Nitrogen was determined on air dried leaf sample by the Macro Kjeldahl method.

Of all the minerals present in the foliage of trees examined in this region Ca is by far in greater amount and the "influence of the calcium outweighs that of all the other bases combined. This is owing in part to the relatively large amount of calcium present, as well as to the nature of the cation" (Chandler, 1939, p. 4).

The calcium content of tree foliage has a marked effect on (1) pH and base status of the surface layers of the soil, (2) the population of micro-organisms under tree stands, (3) the rate of decomposition of tree litter and availability of minerals and plant nutrients in the surface layers, and (4) physical characteristics of the soil. The nitrogen content similarly determines the population of micro-organisms, the rate of decomposition of tree litter and availability of nitrates. In short, Ca and N determine to a great extent the type of humus that develops under a forest stand, and the type of forest that may succeed the present tree community (Puri, 1950). Determinations were, therefore, made only of ash, CaO and nitrogen content in fresh mature leaves of trees.

The average results for ash, CaO and N are presented in Table 1. In the table species are arranged alphabetically.

TABLE 1.—*Composition of fully grown mature leaves of some important species in the sal forest of the Dun Valley*

(Data partly published by Puri and Gupta, 1950)

Serial No.	Species	Ash %	Ca %	Carbon %	N %	C/N
1	*Acacia catechu*	5·95	2·03	46·08	4·18	11·02
2	*Aegle marmelos*	9·52	3·91	44·6	3·46	12·89
3	*Adhatoda vasica*	15·20	5·07	41·9	3·04	13·7
4	*Albizzia procera*	5·54	1·55	46·79	3·21	14·57
5	*Alstonia scholaris*	10·86	3·17	44·17	2·99	14·1
6	*Adina cordifolia*	5·22	1·64	47·27	2·59	18·25
7	*Anogeissus latifolia*	7·88	3·22	46·08	2·26	20·3
8	*Ardisia humilis*	15·10	4·22	42·7	1·54	27·7
9	*Bassia latifolia*	6·29	1·93	47·08	1·89	24·9
10	*Bauhenia* sp.	6·76	2·21	46·5	2·48	18·7
11	*Bauhenia malabarica*	8·83	3·52	45·6	2·18	20·9
12	*Bauhenia purpurea*	14·55	4·03	42·3	2·94	14·3
13	*Bauhenia retusa*	7·85	3·73	46·2	2·03	22·7
14	*Bauhenia vahlii*	7·65	2·05	46·19	2·27	20·3
15	*Bischofia javanica*	17·35	5·39	41·6	1·53	27·18
16	*Bridelia retusa*	10·75	1·30	44·2	3·01	14·6
17	*Buchanania latifolia*	11·90	2·42	44·3	1·62	27·3
18	*Butea frondosa*	6·78	2·31	46·37	2·80	16·5
19	*Careya arborea*	12·24	3·02	44·1	1·75	25·2
20	*Carissa spinarum*	6·12	1·33	47·15	1·92	24·5
21	*Casearia tomentosa*	10·53	3·17	44·79	2·12	21·1
22	*Cassia fistula*	8·08	3·08	45·8	2·59	17·6
23	*Cedrela toona*	9·45	2·68	45·16	2·48	18·2
24	*Cinnamomum camphora* (planted) ..	6·5	1·91	47·1	1·63	28·89
25	*Clerodendron infortunatum* ..	8·01	2·67	46·01	2·26	20·3
26	*Colebrookea oppositifolia* ..	12·27	3·31	43·9	2·08	21·1
27	*Cordia myxa*	12·55	4·93	43·7	2·19	19·9
28	*Dalbergia sissoo*	9·81	2·63	44·3	3·73	11·87
29	*Ehretia laevis*	7·99	2·09	46·05	2·21	20·8
30	*Eugenia jambolana*	7·37	2·35	46·6	1·74	26·78
31	*Eugenia operculata*	7·27	3·20	46·78	1·49	31·39
32	*Ficus cunia*	17·94	4·73	41·05	2·00	20·5
33	*Ficus glomerata*	15·65	6·30	41·88	2·68	15·6
34	*Ficus hispida*	22·30	3·84	38·76	2·10	18·4
35	*Flacourtia ramontchi*	6·60	2·21	46·65	2·42	19·3
36	*Flemingia chappar*	7·07	2·02	46·24	2·75	16·8
37	*Fleuggia microcarpa*	8·28	2·97	45·79	2·42	18·9
38	*Gardenia turgida*	8·70	2·09	45·66	2·25	20·2
39	*Garuga pinnata*	11·95	3·59	44·15	1·94	22·7
40	*Grewia oppositifolia*	11·75	4·40	43·90	2·64	16·6
41	*Grewia vestita*	10·03	3·28	44·87	2·47	18·16

TABLE 1.—*Composition of fully grown mature leaves of some important species in the sal forest of the Dun Valley*—(contd.)

(Data partly published by Puri and Gupta, 1950)

Serial No.	Species	Ash %	Ca %	Carbon %	N %	C/N
42	*Helicteres isora*	11·15	2·44	44·07	2·91	15·14
43	*Holoptelea integrifolia*	16·09	6·53	41·46	3·06	13·5
44	*Hollarhena antidysenterica* ..	8·39	2·25	45·6	2·61	17·47
45	*Hymenodictyon excelsum* ..	10·05	2·21	44·9	2·36	19·0
46	*Kydia calycina*	16·27	6·00	41·9	1·96	21·37
47	*Lagerstroemia parviflora* ..	6·24	1·58	47·1	1·91	24·66
48	*Limonia acidissima*	12·70	4·12	43·4	2·58	16·8
49	*Litsaea chinensis*	5·60	1·15	47·16	2·42	19·48
50	*Litsaea polyantha*	7·65	2·12	46·36	1·94	23·89
51	*Loranthus longiflorus*	11·95	2·82	44·3	1·62	27·3
52	*Machilus* sp.	6·87	1·41	46·87	1·72	27·25
53	*Mallotus philippinensis*	7·83	1·64	45·66	3·29	14·59
54	*Mangifera indica*	6·95	2·38	47·06	1·27	37·0
55	*Miliusa velutina*	6·97	1·61	46·6	2·10	22·20
56	*Milletia auriculata*	9·62	2·81	44·35	3·88	11·4
57	*Morus alba*	12·80	4·12	43·89	1·61	27·26
58	*Murraya koenigii*	12·26	3·89	43·48	2·94	14·79
59	*Nyctanthus arbor-tristis*	14·04	3·63	43·3	1·46	29·66
60	*Oroxylum indicum*	10·72	3·19	44·4	2·61	17·01
61	*Ougeinia delbergioides*	9·47	3·57	45·2	2·39	18·9
62	*Phyllanthus emblica*	4·48	1·93	47·99	1·94	24·7
63	*Randia dumetorum*	9·42	2·51	45·59	1·77	25·75
64	*Salix tetrasperma*	10·05	2·71	45·06	2·07	21·76
65	*Semecarpus anacardium*	9·67	3·36	45·4	1·80	25·2
66	*Shorea robusta*	5·38	1·46	47·76	1·47	31·8
67	*Stephegyne parviflora*	7·00	2·27	46·8	1·65	28·36
68	*Sterculia villosa*	8·50	2·70	45·97	1·84	24·99
69	*Stereospermum suaveolens* ..	13·48	1·67	43·4	1·81	23·97
70	*Tectona grandis*	8·35	2·91	46·7	1·55	30·01
71	*Terminalia arjuna*	9·72	1·17	45·25	2·04	22·18
72	*Terminalia belerica*	11·54	4·41	44·4	1·81	24·5
73	*Terminalia chebula*	7·79	2·75	46·4	1·73	26·8
74	*Terminalia tomentosa*	8·19	3·00	45·96	2·18	21·08
75	*Trewia nudiflora*	11·60	3·05	44·3	2·01	21·9
76	*Woodfordia fruticosa*	6·32	2·30	46·9	2·20	21·3
77	*Ventilago calyculata*	12·45	5·63	43·57	2·57	16·9
78	*Zizyphus xylopyra*	6·78	1·82	46·78	1·98	23·6

The species studied enter into the composition of different types of forests extending from Assam in the East, and Ganjam in the South to Punjab in the North-West, and have a different frequency distribution due to differences in soil conditions and climate. The ecological status, or even the exact systematic position, viz., eco-type, geno-type, etc., of sal in

different parts of the country is not clearly known. According to Champion (1933) it may be a climatic climax with one set of associates in one area and in others it may be a post-climax or pre-climax with the same or another set of species. It cannot be therefore, expected that *Shorea robusta*, or any of its associates will have exactly the same amounts of ash and CaO in their foliage in different conditions, as are found in the Dehra Dun Valley on the Siwalik clays. These sal forests on the Siwalik clays represent a bio-edaphic community and are seral in nature. On conglomerates the sal community has a larger proportion of other forest species. Both these communities are seral and more or less stable under the present factors of the environment.

From the table, it appears that foliar ash, CaO and N in the species studied show a good deal of difference and accounting for small variations that may be found in trees of the same species growing in different climates and soils, the differences in foliar constituents shown herein in different species growing in these forests in a more or less uniform climate indicates that they have not only marked different physiological demands on soil minerals, especially lime, but their effects on the development of the humus layer and vegetation in the forest may also be different.

Foliar CaO in *Shorea robusta* is very low and it is higher only than *Pinus longifolia Litsaea chinensis, Carissa spinarum, Machilus* sp. and *Bridelia retusa.*

The highest figures for CaO (above 6 per cent) are found in leaves of *Kydia calycina, Ficus glomerata* and *Holoptelea integrifolia.*

The species with low foliar Ca are non-exacting and those which contain high percentage of foliar CaO are exacting on soil bases. Species can be grouped together in a number of classes on foliar CaO and these groups occupy different types of soil in the Dehra Dun forests.

1. A III quality sal occurs in association with *Lagerstroemia parviflora, Machilus* sp., *Phyllanthus emblica, Litsaea chinensis, Mallotus philippinensis, Stereospermum suaveolens, Miliusa velutina,* etc., on the Siwalik clays at Asarori. The foliar CaO in these species is usually below 2 per cent. *Chir* pine is invading these sal forests and foliar CaO in this species is also below 2·0%.

2. A mixed sal forest, occurs in the Dun Valley at several places on shallow clayey soils, with conglomerate on the surface or very near it. The chief associates of sal in the upper storey are *Eugenia jambolana* and *Terminalia tomentosa,* though in rare cases *Terminalia belerica* may also be present. In the second storey and shrub layer, depending upon the nature of the soil, there occur *Casearia tomentosa, Buchanania latifolia, Ougeinia dalbergioides, Woodfordia fruticosa, Grewia vestita, Litsaea polyantha, Clerodendron infortunatum* and *Colebrookea oppositifolia.* The foliar CaO in most of these species is between 2–3·50%, though in *Terminalia belerica,* which is rather rare in this forest, foliar Ca is 4·41%.

3. *Anogeissus latifolia, Bauhenia retusa, Casearia tomentosa, Nyctanthes arbor-tristis, Cassia fistula, Elaeodendron glaucum, Eugenia operculata, Ougeinia dalbergioides,* etc., contain between 3–4 per cent of foliar CaO and form a pure miscellaneous forest or with a low quality and low percentage of sal at Maidan hill and other places in the Valley.

4. *Grewia vestita, G. oppositifolia, Anogeissus latifolia, Careya arborea, Semecarpus anacardium, Kydia calycina, Ficus cunia,* etc., contain more than 4 per cent of foliar CaO and form a miscellaneous community without sal, on calcareous conglomerate outcrops on scarp slopes (Kansrao) or steep slopes by streams (Lachiwala) in the Dun Valley.

5. On a riverain habitat on a calcareous fine gravel there occurs a miscellaneous community of *Trewia nudiflora, Limonia acidissima, Ardisia humilis, Holoptelea integrifolia,*

Aegle marmelos, *Adhatoda*, etc. The foliar Ca in most of these is between 4–6·50, though in *Trewia nudifolra* it is only 3·05%.

The data for foliar CaO seem to show that species with similar requirements for soil calcium tend to occur on a similar type of substratum.

The data for foliar N also shows a good deal of variations in different species. The highest amount above 4·0%, is found in *Acacia catechu* and the lowest figure of 1·47% is for *Shorea robusta*. *Mangifera indica* has still lower foliar N of 1·27% only.

On the whole, *Leguminoseae* species have higher amounts of foliar N than other species. They are associated with bacterial nodules which fix atmospheric nitrogen. *Dalbergia sissoo*, which forms a pioneer community with *Acacia catechu* on newly laid river alluvia at many places has a foliar N of 3·73%. Another species on alluvial soils, *Holoptelea integrifolia*, has 3·06% foliar N. Foliar N of *Mallotus* is fairly high (3·29%) and other evergreen species in the undergrowth in sal forests, namely, *Clerodendron* and *Colebrookea* have a foliar N above 2%. The high foliar nitrogen in species occurring on river alluvia does not necessarily indicate a high nitrate content of the substratum. These species fix atmospheric nitrogen and usually occur in localities with little or no organic matter in the soil. But those forest species which do not possess root nodules and still have higher foliar nitrogen, surely indicate high nitrate content in soils.

It may be noted that these analysis were made on leaves collected in Oct.–Nov. when foliar nitrogen in most trees is usually at a lower level than in April–May. Since the nitrogen requirements of forest species is fairly heavy there are strong reasons that organic matter content in forest soils, which is almost the only source of nitrogen for plants, should be kept at a high level. Burning and removal of tree litter should be discouraged.

The litter of sal has a low amount of nitrogen and as its Ca content is also low, its decomposition in nature is slow and the fertility conditions in areas with pure sal litter are, therefore, not high. Most of the associates of sal have higher foliar nitrogen. The mixed litter is, therefore, not only decomposed quickly but it provides a higher level of soil fertility. It has been noticed that in sal forests the regeneration of sal is better in those situations where mixed humus is present. The secret of the superiority of mixed humus over humus of pure sal is that the former has a higher level of nitrogen and also CaO. But since sal is a calcifuge a higher amount of CaO in the humus may not be a favourable factor but higher amount of nitrogen is certainly desired for better and quicker growth of sal.

This study, though preliminary seems to make it abundantly clear that species occurring in this area have different demands on soil minerals and nitrogen, and seem to show differences in physiological requirements. They may, therefore, react differently to one and the same type of silvicultural operation. The different types of silvicultural operations essentially upset the normal physiological and ecological balance in a community favouring or stimulating seedling growth at the expense of other ground flora communities. Thus, the exact knowledge of physiological changes in a community is essential. A fuller examination of this question will be dealt with later on.

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RELATIONSHIP BETWEEN THE AVERAGE DIAMETERS OF THE MAIN AND THE SUBSIDIARY CROPS IN THE CASE OF PLANTATION TEAK (*TECTONA GRANDIS*, LINN. F.)

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During the preparation of the new teak yield tables the author had an opportunity, last year, of examining the influence of site quality and intensity of thinnings on the relationship between average* diameters of the main and the subsidiary crops in the case of plantation teak. As the results of this small investigation do not find a place in the main publication, they are presented in the shape of this small note.

The data utilized here comes from permanent sample plots laid out in different parts of the Indian Union from 1917 onwards. The work in these plots has been carried out on standardized lines described in "The Silviculture Research Code Vol. 3 – The Tree and Crop Measurement Manual", and the thinnings as a rule were marked carefully by experienced forest officers. The available figures for main and subsidiary crop average diameters were sorted out separately for the 'C' and 'D' grades of ordinary thinnings by one inch diameter classes and the four site qualities adopted for the new yield tables. The entries in each cell were next averaged. By pooling up the data, averages (i) for all the site qualities within either of the two thinning grades and (ii) for all the site qualities and the two thinning grades taken together were further calculated. Table 1 gives the averages so derived along with the number of measurements on which they are based.

The subsidiary crop average diameters were then plotted against the reciprocal values of the main crop average diameter (Fig. 1), using different notations for the four site qualities and the two thinning grades. The distribution of these points indicates clearly that, in the case of teak, the relationship between average diameters of the main and the subsidiary crop is independent of site quality and thinning intensity within the range of 'C' and 'D' grades of ordinary thinnings. In order to examine the influence of variation in thinning intensity more closely, the second set of averages of table 1 (i.e., averages of the entire data within either of the two grades taken together) were plotted separately in Fig. 2. This confirmed the previous conclusion regarding the influence of thinning intensities – i.e., the grade of thinning does not exercise any influence on the resulting subsidiary and main crop diameter relationship.

The points representing the final averages were then plotted in figure 2 and a free hand curve† was fitted to the same. This gives the desired relationship between the average

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* Average diameter corresponding to the average stem basal area obtained by dividing the total basal area by the number of stems.

† The question of fitting a regression curve to these points was considered. A first degree curve was ruled out because the points show a definite tendency for slight curvature up to the 5-inch main crop diameter limit though beyond this point the curve has obviously to be a straight line. The second degree equation curve fitted to the data does not give a good fit and the attempt was given up as it is primarily of a theoretical interest.

diameters of the main and the subsidiary crops for plantation teak. Readings from this curve are given in Table 2.

ACKNOWLEDGEMENTS

The computational work connected with this note was done primarily by Shri M. M. Singh, Computor while the two graphs have been prepared by Shri A. S. Rawat, Head Computor and Shri P. S. Dangwal, Surveyor.

TABLE 2.—*Final values of the corresponding main and subsidiary crop average diameters for plantation teak*

Main crop average diameter (inches)	Subsidiary crop average diameter (inches)	Main crop average diameter (inches)	Subsidiary crop average diameter (inches)
		12·0	9·8
2·3	2·3	13·0	10·7
2·5	2·4	14·0	11·5
3·0	2·6	15·0	12·4
3·5	2·9	16·0	13·2
4·0	3·2	17·0	14·1
4·5	3·5	18·0	15·0
5·0	3·9	19·0	15·8
5·5	4·3	20·0	16·6
6·0	4·8	21·0	17·5
7·0	5·6	22·0	18·3
8·0	6·4	23·0	19·2
9·0	7·3	24·0	20·0
10·0	8·1	25·0	20·8
11·0	9·0	26·0	21·7

Fig. 1.

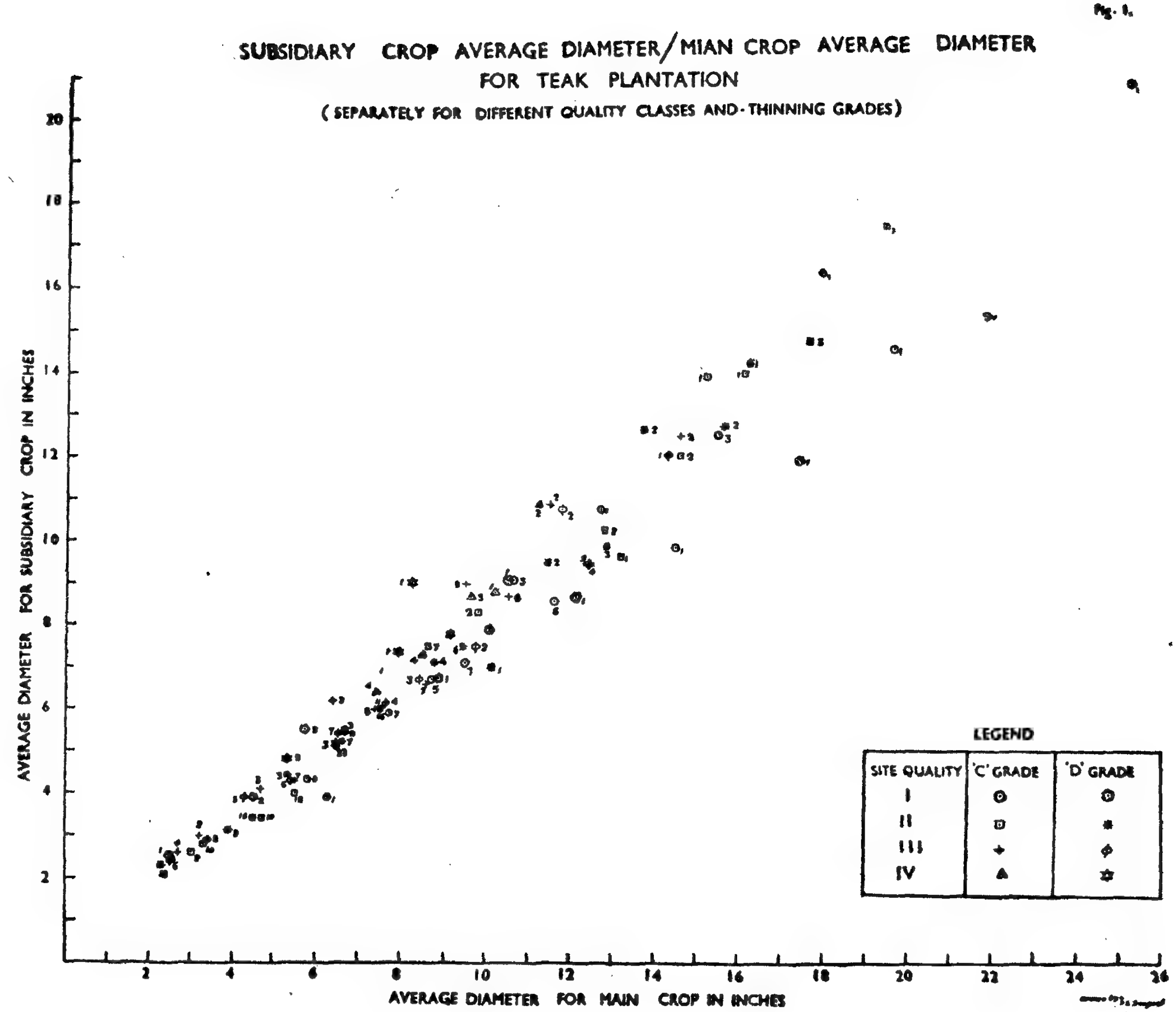
SUBSIDIARY CROP AVERAGE DIAMETER/MIAN CROP AVERAGE DIAMETER
FOR TEAK PLANTATION
(SEPARATELY FOR DIFFERENT QUALITY CLASSES AND THINNING GRADES)
AVERAGE DIAMETER FOR SUBSIDIARY CROP IN INCHES
AVERAGE DIAMETER FOR MAIN CROP IN INCHES
2
4
6
8
10
12
14
16
18
20
22
24
26
LEGEND
SITE QUALITY
'C' GRADE
'D' GRADE
I
II
III
IV

Fig. 2.

SUBSIDIARY CROP AVERAGE DIAMETER/MAIN CROP AVERAGE DIAMETER FOR TEAK PLANTATION

(ALL THE QUALITY CLASSES TAKEN TOGETHER)

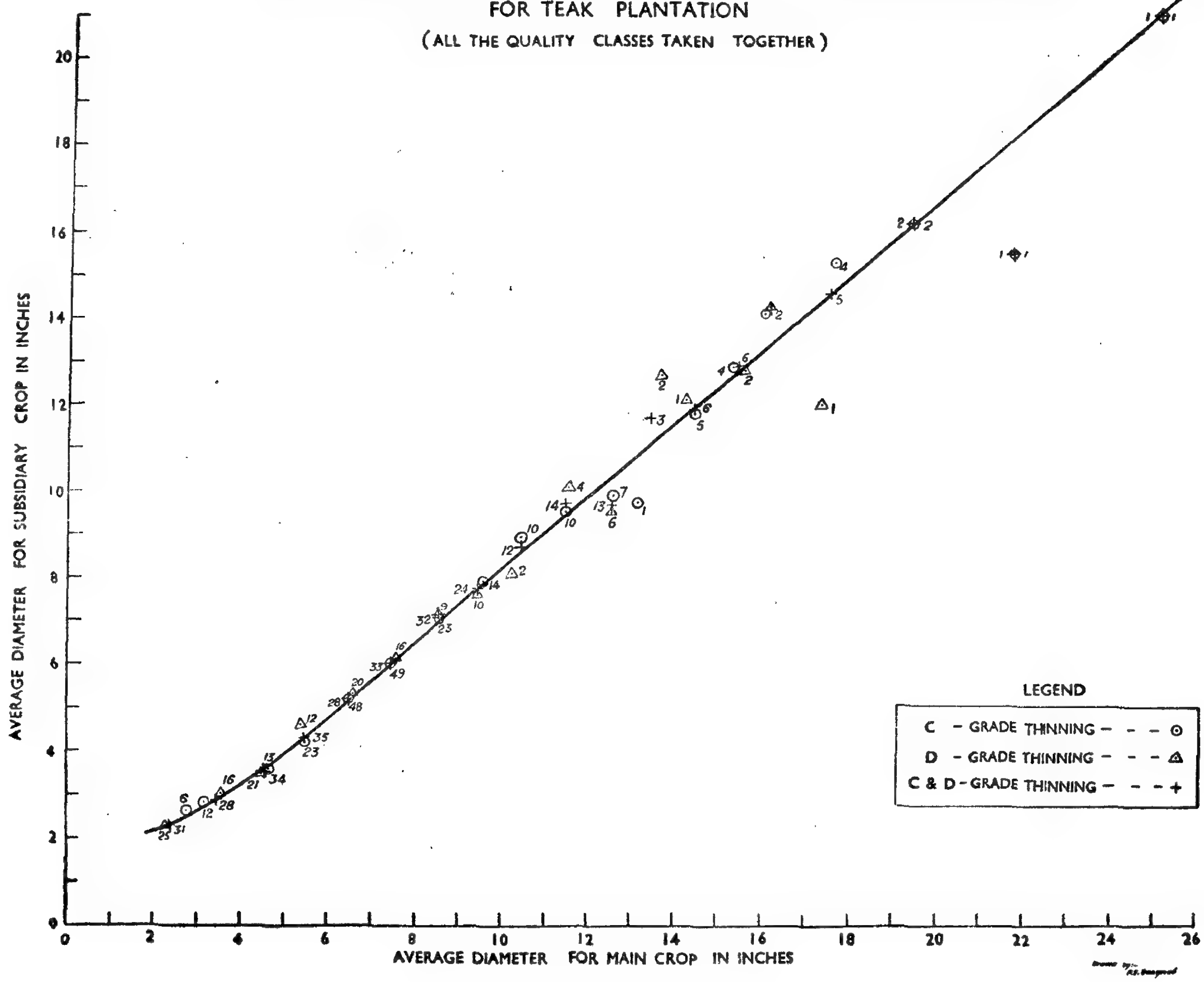

TABLE 1.—*Basic sample plot data for the main and subsidiary crop average diameters by site qualities and thinning grades*

DIAMETER CLASS (INCHES)

Thinning grade	Quality class		2·1 3·0		3·1–4·0		4·1–5·0		5·1–6·0		6·1–7·0		7·1–8·0		8·1–9·0		9·1–10·0	
			Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop
C	I	Average diameter	..	..	..	.	..	..	5·8	4·3	6·3	3·9	7·7	5·9	8·7	6·7	9·5	7·1
		Number of measurements ..	..		..		..		(4)		(1)		(7)		(5)		(7)	
	II	Average diameter ..	3·0	2·6	3·3	2·8	4·7	3·4	5·5	4·0	6·5	5·1	7·5	6·0	8·6	7·5	9·8	8·3
		Number of measurements ..	(2)		(10)		(10)		(12)		(23)		(14)		(7)		(2)	
	III	Average diameter ..	2·7	2·6	3·2	3·0	4·7	4·1	5·5	4·3	6·4	6·2	7·4	6·0	8·6	6·6	9·5	9·0
		Number of measurements ..	(4)		(2)		(3)		(7)		(2)		(8)		(7)		(2)	
	IV	Average diameter ..	..	..	.	..		.	..	..	6·7	5·5	7·4	6·4	8·5	7·3	9·6	8·7
		Number of measurements ..	..		..		..		..		(2)		(4)		(4)		(3)	
	I to IV	Average diameter ..	2·8	2·6	3·2	2·8	4·7	3·6	5·5	4·2	6·5	5·2	7·5	6·0	8·6	7·0	9·6	7·9
		Number of measurements ..	(6)		(12)		(13)		(23)		(28)		(33)		(23)		(14)	
D	I	Average diameter ..	2·5	2·5	..	..	4·5	3·9	5·7	5·5	6·7	5·5	..	..	8·8	6·7	10·0	7·9
		Number of measurements ..	(1)		..		(2)		(2)		(3)		..		(1)		(1)	
	II	Average diameter ..	2·3	2·3	3·9	3·1	4·5	3·4	5·3	4·4	6·6	5·2	7·5	6·0	8·7	7·1	9·4	7·5
		Number of measurements ..	(18)		(8)		(16)		(3)		(7)		(11)		(4)		(6)	
	III	Average diameter ..	2·5	2·4	3·4	2·9	4·3	3·9	5·4	4·3	6·5	5·4	7·6	6·1	8·4	6·7	9·7	7·5
		Number of measurements ..	(6)		(8)		(3)		(5)		(7)		(4)		(3)		(2)	
	IV	Average diameter ..	..	..	..	..	..	..	5·3	4·8	6·5	5·2	7·9	7·4	8·2	9 0	9·1	7·8
		Number of measurements ..	..		..		..		(2)		(3)		(1)		(1)		(1)	
	I to IV	Average diameter ..	2·3	2·3	3·6	3·0	4·5	3·5	5·4	4·6	6·6	5·3	7·6	6·1	8·6	7·1	9·5	7·6
		Number of measurements ..	(25)		(16)		(21)		(12)		(20)		(16)		(9)		(10)	
C & D combined	I to IV	Average diameter ..	2·4	2·3	3·5	2·9	4·6	3·5	5·5	4·3	6·5	5·2	7·5	6·0	8·6	7·1	9·5	7·7
		Number of measurements ..	(31)		(28)		(34)		(35)		(48)		(49)		(32)		(24)	

Thinning grade	Quality class		10·1–11·0		11·1–12·0		12·1–13·0		13·1–14·0		14·1 15·0		15·1 16·0		16 1–17·0		17·1–18·0		19·1 20·0		21·1–22·0		25·1–26·0	
			Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop	Main crop	Sub. crop
C	I	Average diameter	10·6	9·1	11·6	8·6	12·7	10·8	..	.	14·5	9·9	15·5	12·6	..	..	17·9	16·5	19·6	14·7	21·8	15·5	25·2	21·0
		Number of measurements ..	(3)		(6)		(1)		..		(1)		(3)		..		(1)		(1)		(1)		(1)	
	II	Average diameter ..	..	..	..	..	12·8	10·3	13·2	9·7	14·6	12·1	15·2	14·0	16·1	14·1	17·6	14·9	19·4	17·6	..		..	..
		Number of measurements ..	..		..		(2)		(1)		(2)		(1)		(1)		(3)		(1)		..		..	
	III	Average diameter ..	10·5	8·7	11·5	10·9	12·4	9·5	..	..	14·6	12·6	..	..	..	..	..	..	..	..	..	..	..	..
		Number of measurements ..	(6)		(2)		(4)		..		(2)		..		.		..		..		..		.	
	IV	Average diameter ..	10·2	8·8	11·2	10·9	..	..	..	..	..	..	.	..	..	..	..	..	..	..	..	..	..	..
		Number of measurements ..	(1)		(2)		..		..		..		..		..		..		..		..		..	
	I to IV	Average diameter ..	10·5	8·9	11·5	9·5	12·6	9·9	13·2	9·7	14·5	11·8	15·4	12·9	16·1	14·1	17·7	15·3	19·5	16·2	21·8	15·5	25·2	21·0
		Number of measurements ..	(10)		(10)		(7)		(1)		(5)		(4)		(1)		(4)		(2)		(1)		(1)	
D	I	Average diameter ..	10·5	9·1	..	..	12·1	8·7	..	..	..	..	..	..	..	..	17·4	12·0	..	..	..	..	..	..
		Number of measurements ..	(1)		..		(1)		..		..		..		..		(1)		..		..		..	
	II	Average diameter ..	10·1	7·0	11·4	9·5	12·8	9·9	13·7	12·7	..	..	15·6	12·8	16·2	11·3	..	..	..	..	..	..	..	..
		Number of measurements ..	(1)		(2)		(3)		(2)		..		(2)		(1)		..		..		..		..	
	III	Average diameter ..	..	..	11·8	10·8	12·4	9·5	..	..	14·3	12·1	..	..	..	..	..	..	..	..	..	..	..	..
		Number of measurements ..	..		(2)		(2)		..		(1)		..		..		..		..		..		..	
	IV	Average diameter ..	..	..	..	..	..	..	..	..	..	..	..	.	.	..	.	..	..	..	..	..	..	..
		Number of measurements ..	..		..		..		..		..		..		..		..		.				..	
	I to IV	Average diameter ..	10·3	8·1	11·6	10·1	12·6	9·6	13·7	12·7	14·3	12·1	15·6	12·8	16·2	14·3	17·4	12·0	..	..	..	..	..	..
		Number of measurements ..	(2)		(4)		(6)		(2)		(1)		(2)		(1)		(1)		..		..		..	
C & D combined	I to IV	Average diameter ..	10·5	8·7	11·5	9·7	12·6	9·7	13·5	11·7	14·5	11·9	15·5	12·9	16·2	14·2	17·6	14·6	19·5	16·2	21·8	15·5	25·2	21·0
		Number of measurements ..	(12)		(14)		(13)		(3)		(6)		(6)		(2)		(5)		(2)		(1)		(1)	

INDIGENOUS CELLULOSIC RAW MATERIALS FOR THE PRODUCTION OF PULP, PAPER AND BOARD

PART XXIII.—CHEMICAL PULPS AND WRITING AND PRINTING PAPERS FROM *SACCHARUM PROCERUM* ROXB. (*BHUTANG*)

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SUMMARY

Laboratory experiments on the sulphate pulping of *Saccharum procerum* Roxb. (*bhutang*) are described. Two pilot plant trials were carried out. The average fibre length of the pulp from *bhutang* is 2·30 mm. Easy bleaching pulps in yields considerably higher than usually obtained from bamboo or sabai grass were obtained. Writing and printing papers made on the pilot plant were characterized by good formation and satisfactory strength properties. Two samples of papers made from *bhutang* are appended in this bulletin.

INTRODUCTION

Saccharum procerum Roxb. is known as *bhutang* in Assam. It is a very tall grass with culms up to about 16 feet in length. The stem is solid and smooth. The leaf blades are up to 5 feet long and 2 inches wide ; they taper to a fine point and are very rough on the margins. The inflorescence is large and silvery or grey ; the panicle is loose. This species flowers in the month of January.

Saccharum procerum Roxb. resembles very closely *Saccharum arundinaceum* Retz. ; but the latter can be distinguished by its having much taller leaf stems, up to about 19 feet. The leaves of *S. arundinaceum* are considerably broader. The inflorescence in this case is less silvery, rather pinkish white ; the panicle is not so loose as in the case of *S. procerum*. *S. arundinaceum* flowers at the end of the rainy season.

Saccharum peocerum is very common in the wet low-lying places in the plains and also in the hills up to an altitude of 3,000 feet in Assam, Bengal and Burma. According to the information supplied by the Senior Conservator of Forests, Assam, *bhutang* grass is found in large quantities in the Mikir and Naga Hills (Dhansiri Valley, Nowgong and Sibsagar Divisions) and about 10,000 tons of this grass are available per annum in these Divisions. This grass is not put to any use in Assam. Therefore, the Senior Conservator of Forests, Assam, suggested that an investigation might be undertaken on the pulping and paper-making qualities of this grass. The results of the investigation are described in this bulletin.

THE RAW MATERIAL

For the laboratory experiments, *bhutang* grass (75 lb.) was received from the Beat Officer, Dimapur Forest Beat, Assam. For the pilot plant trials, the Range Officer, Southern Range, Rangapahar (Assam), supplied 2 tons of this grass. The supplies consisted of stems, 8 feet in length and $\frac{1}{2}$–1 inch in diameter. The colour of the stems was pale brown. The moisture content of the grass as received was 11·4% (expressed on the basis of oven-dry material).

The stems contained an inner solid core of pith interspersed with fibres. The pith constituted about 17% of the whole stem.

The stems were crushed between the rollers of the factory bamboo crusher, cut into lengths of about 1 inch, and screened on the factory screen. The screened material was used for this investigation.

PROXIMATE CHEMICAL ANALYSIS

The screened pieces of the grass were reduced to dust in the usual way. The dust passing through 60-mesh and retained on 80-mesh was used for the analysis using TAPPI standard methods. The results of the analysis are recorded in Table I. The moisture content of the dust used for the analysis was about 6·5%.

TABLE I

Proximate chemical analysis of Saccharum procerum

		% on the oven-dry basis
1.	Ash	3·23
2.	Cold water solubility	5·23
3.	Hot water solubility	6·81
4.	1% NaOH solubility	26·51
5.	Ether solubility	0·33
6.	Alcohol-benzene solubility	1·49
7.	Pentosans	21·89
8.	Lignin	21·76
9.	Cellulose (Cross and Bevan)	63·46

The results recorded in Table I indicate that *bhutang* is a suitable raw material for investigation on its suitability for paper pulp.

FIBRE DIMENSIONS

The crushed, cut and sieved pieces of the grass were digested by the sulphate process ($NaOH : Na_2S = 2 : 1$) using 17% total chemicals (on the basis of the oven-dry raw material) in 34 g./litre concentration at 142°C. for 6 hours. The pulp was bleached and fibre length and diameter determinations were carried out in the usual way. The fibre dimensions are given in Table II. The fibre length distribution is given in Table III and fibre diameter distribution in Table IV.

TABLE II

Fibre dimensions

	Fibre length mm.	Fibre diameter mm.
Minimum	0·51	0·008
Maximum	5·48	0·031
Average	2·30	0·018

The ratio of the average fibre length to diameter = 128 : 1.

TABLE III

Fibre length distribution

Fibre length mm.	Number of fibres	% of fibres
0·51 to 1·00	26	13·0
1·01 to 2·00	61	30·5
2·01 to 3·00	60	30·0
3·01 to 4·00	33	16·5
4·01 to 5·00	14	7·0
5·01 to 5·48	6	3·0
TOTAL	200	100·0

TABLE IV

Fibre diameter distribution

Fibre diameter mm.	Number of fibres	% of fibres
0·005 to 0·010	16	8·0
0·011 to 0·015	34	17·0
0·016 to 0·020	106	53·0
0·021 to 0·025	26	13·0
0·026 to 0·030	16	8·0
0·031 to 0·035	2	1·0
TOTAL	200	100·0

PRODUCTION OF PULP

The crushed, cut and sieved material was digested by the sulphate process using $NaOH : Na_2S = 2 : 1$. The material – liquor ratio was 1 : 5. The digestions were carried out in a 3-litre capacity mild steel autoclave under various conditions recorded in Table V. The pulp was washed on 66-mesh sieve and bleached with bleaching powder in two stages. The first stage of the bleaching was carried out at 35°C. with about 75% of the total bleach requirement. After the first stage of bleaching, the pulp was washed and treated with 2% caustic soda (on the basis of the oven-dry pulp) at 70°C. for 1 hour. The pulp was then washed and bleached with the bleaching powder. The pulp bleached easily and well.

The bleached pulp was beaten in the Lampen Mill to about 300 c.c. (C.S.F.) freeness. Standard pulp sheets were made from this beaten pulp on the sheet making machine and dried in the air using rings and plates. The pulp sheets were conditioned at 65% R.H. and 74°F. and tested for their strength properties. The brightness of the pulp sheets was determined using the Photoelectric Reflection Meter Model 610.

The digestion conditions, pulp yields, bleach consumption and strength properties and brightness of pulp sheets are recorded in Table V.

PILOT PLANT TRIALS

In order to confirm that *bhutang* is a suitable fibrous raw material for the production of writing and printing papers, two pilot plant experiments were carried out. About 650 lb. of *bhutang* grass (on the basis of the oven-dry material) were used in each digestion. The cooking was carried out in a vertical stationary mild steel digester of forced circulation – indirect heating type. The temperature of the contents of the digester was brought to the cooking temperature from 70°C. in 1½ hours and the cooking was continued for 3 hours more. After the digestion, the pulp was washed in the potcher. The unbleached pulp was of light grey colour. The pulp was bleached with bleaching powder in two stages. The intermediate alkali treatment during bleaching was not used in the pilot plant experiments. The bleached pulp was beaten in the factory beater, rosin size, alum, china clay and ultramarine blue (for tinting) were added and writing and printing papers were made on the Fourdrinier machine of the Institute. A sample each from these two trials is appended in this bulletin.

The digestion conditions, pulp yields and bleach consumption are given in Table VI and strength properties of papers in Table VII.

DISCUSSION

The results recorded in Table V indicate that bleached pulp in high yields can be prepared from *bhutang* grass by the sulphate process. The yields of the pulps decrease when the temperature of cooking is increased from 142° to 162°C. and also when the quantity of chemicals for cooking is increased from 17% to 19%. The increase in the period of cooking from 4 to 6 hours also affects the pulp yields adversely.

The bleach consumption is satisfactory. It is, however, lower in the case of cooks where 19% chemicals are used for digestion than in the corresponding cooks where 17% chemicals are used. The increase in the period of cooking from 4 to 6 hours does not seem to affect the bleach consumption of pulps appreciably.

When the quantity of chemicals used for cooking is increased from 17% to 19%, there is no appreciable change in the strength properties of the pulps except in the case of folding resistance. The pulp obtained from the cook with 19% chemicals at 162°C. for 4 hours has a higher folding resistance than the corresponding pulp obtained by cooking with 17% chemicals.

The conditions recorded in Serial Nos. 3 and 7, Table V, seem to be preferable for preparing pulp from *bhutang* grass for writing and printing papers.

The results of the pilot plant trials recorded in Table VI confirm that easy bleaching pulps in high yield can be prepared from *bhutang* grass by the sulphate process. The writing and printing papers made from *bhutang* were characterized by good formation and satisfactory strength properties. The whiteness of the papers was quite good. Since the average fibre length of pulps from *bhutang* grass is 2·30 mm., it seems that good quality writing and printing papers can be made from the pulp of this grass without admixture with pulp from bamboo, etc.

This investigation has shown that *bhutang* grass can be pulped under milder conditions than bamboo. The yields of unbleached and bleached pulps are considerably higher than in the case of bamboo. Whereas bleached pulps in about 35% and 40% yields are usual in the case of sabai grass and bamboo respectively, *bhutang* grass gives 51–56% bleached pulp.

The fibre length of sabai grass is about 2 mm., whereas that of *Dendrocalamus strictus* (bamboo) is about 3 mm. Therefore, bamboo papers will be superior in tearing resistance although the strength properties of *bhutang* papers including tearing resistance are satisfactory. Since the Senior Conservator of Forests, Assam, has reported *bhutang* as a weed in Assam and since this grass is not put to any use in Assam, this grass should be available at a cheap price. Because of transport difficulties in exporting such materials from Assam to other States in this country, it is suggested that *bhutang* grass available in Assam forests should be used for paper manufacture in Assam only. At present, no paper or pulp mill exists in Assam. Since *bhutang* grass seems to be a more economic fibrous raw material than sabai grass or bamboo for paper manufacture, raising of this grass in suitable areas in other States seems to be worth-while attempting.

CONCLUSIONS

1. Bleached pulps in 51–56% yield can be prepared from *Saccharum procerum* (*bhutang*). The bleach consumption is considerably lower than in the case of bamboo pulps.

2. The average fibre length of pulps from *bhutang* is 2·30 mm.

3. Writing and printing papers of good formation and satisfactory strength properties can be prepared from *bhutang* grass. The whiteness of the papers is quite good.

4. *Bhutang* grass seems to be a more economic fibrous raw material than bamboo or sabai grass.

Thanks are given to the Senior Conservator of Forests, Assam, the Range Officer, Southern Range, Rangapahar, Assam, and the Beat Officer, Dimapur Forest Beat, Assam, for the supply of *bhutang* grass for this investigation and for the information regarding the availability of this grass in Assam. Thanks are also due to the Botanist of this Institute for supplying information regarding the botanical description and distribution of this grass.

TABLE V.—*Sulphate digestions of bhutang (Saccharum*

DIGESTION CONDITIONS AND PULP YIELDS								
1	2	3	4	5	6	7	8	9
Serial No.	Total chemicals* (NaOH : $Na_2S=2:1$)	Concentration of chemicals	Digestion temperature	Digestion period	Consumption of chemicals*	Unbleached pulp yield*	Bleach consumption as standard bleaching powder containing 35% available chlorine*	Bleached pulp yield*
	%	g./litre	°C.	hours	%	%	%	%
1	17	34	142	4	14·5	57·0	4·3	54·1
2	17	34	142	6	16·0	57·5	4·2	53·6
3	17	34	153	4	15·8	58·3	4·2	52·3
4	17	34	162	4	16·0	55·5	4·2	51·8
5	19	38	142	4	15·5	57·5	3·6	53·8
6	19	38	142	6	15·9	55·0	3·5	52·2
7	19	38	153	4	16·6	57·0	3·3	50·6
8	19	38	153	6	16·7	54·3	3·2	50·7
9	19	38	162	4	16·7	54·5	3·0	50·6
10	19	38	162	6	18·6	53·2	3·9	48·6

* The % is expressed on the basis of the raw material (oven-dry).

procerum) and strength properties of standard pulp sheets

Strength Properties of Standard Sheets Conditioned at 65% R.H. and 74°F.								
10	11	12	13	14	15	16	17	18
Freeness of pulp	Basis weight	Breaking length (Schopper)	Stretch	Tear factor (Marx-Elmendorf)	Burst factor (Ashcroft)	Folding endurance (Schopper)	Brightness	Remarks
c.c. (C.S.F.)	g./sq. metre	metres	%			double folds		
316	59·6	8650	3·7	85·6	63·5	910	65	A few shives were present.
301	60·0	7440	3·6	88·3	58·7	790	63	In Serial Nos. 2–10 well-cooked, easy bleaching pulps were obtained.
298	59·8	8130	3·0	88·1	62·1	740	65	
305	58·0	7400	3·1	98·6	61·9	770	65	
305	59·6	8530	3·3	85·6	68·2	870	68	
289	60·0	7670	3·0	84·3	57·6	790	63	
298	59·3	7780	3·4	85·0	59·3	780	66	
317	60·3	7660	3·3	93·7	60·5	900	68	
290	59·0	7530	3·3	96·6	61·4	940	68	
330	61·2	7080	3·6	94·6	56·6	680	68	

TABLE VI.—PILOT

Sulphate digestions of bhutang

1	2	3	4	5	6
Serial No.	Total chemicals* (NaOH : Na_2S=2 : 1)	Concentration of chemicals	Digestion temperature	Digestion period	Consumption of chemicals*
	%	g./litre	°C.	hours	%
1	17	34	153	4½	14·5
2	19	38	153	4½	15·7

TABLE VII.—PILOT

Strength properties of papers from pulps described in Table VI. Serial Nos. in this Table

1	2	3	4	5	6		7		8	
Serial No.	Freeness after the addition of size, etc.	Ream weight 17½"×22½"-500	Basis weight*	Thickness	Tensile strength (Schopper)		Breaking length*		Stretch	
	c.c. (C.S.F.)	lb.	g./sq. metre	mils (1/1000 inch)	kg. breaking strain for 1 cm. width		meters		%	
					Machine direction	Cross direction	Machine direction	Cross direction	Machine direction	Cross direction
1	112	20·2	66·5	3·45	3·99	1·90	6000	2860	2·5	3·3
2	87	20·4	67·8	3·50	4·55	2·11	6710	3110	2·2	4·4

* In calculating this, oven-dry weight of the paper was used.

PLANT TRIALS

grass and pulp yields

7	8	9	10
Unbleached pulp yield*	Bleach consumption as standard bleaching powder*	Bleached pulp yield*	REMARKS
%	%	%	
60·3	4·9	56·1	Well-cooked pulp was obtained. The pulp bleached easily. The whiteness of the pulp was good.
57·2	3·8	50·9	Well-cooked pulp was obtained. The colour of the unbleached pulp was lighter than that of Serial No. 1. The pulp bleached easily and the whiteness of the bleached pulp was quite good.

* The % is expressed on the basis of the raw material (oven-dry).

PLANT TRIALS

correspond to the Serial Nos. in Table VI. The papers were conditioned at 65% R.H. and 75°F.

9		10		11	12	13		14
Tearing resistance (Marx-Elmendorf)		Tear factor*		Bursting strength (Ashcroft)	Burst factor*	Folding endurance (Schopper)		REMARKS
g.				lb./sq. inch		double folds		
Machine direction	Cross direction	Machine direction	Cross direction			Machine direction	Cross direction	
48	50	72·2	75·2	22·9	24·2	27	22	Writing paper was made. China clay (12% on the weight of the pulp) was added. A sample is appended.
47	50	69·3	73·8	28·9	30·0	74	43	Printing paper was made. China clay (12% on the weight of the oven-dry pulp) was added. A sample is appended.

TERMINALIA CATAPPA, LINN., ITS SILVICULTURE AND MANAGEMENT

BY DR. K. KADAMBI

Central Silviculturist, Forest Research Institute, Dehra Dun

[Syn. *T. procera* Roxb. Indian Almond Tree. Known in Andamans as "white bombway", a corruption of the Burmese *banbwe* (*Careya arborea*)].

Local names—Bengalee—*Badam*; Kanarese—*Taree*; Tamil—*Natvodami, natbadam, natto-vudumay*; Malayalam—*Adamarram, natbadam*; Telugu—*Vedam, badam, badami*; Uriya—*Badambo.*

Nomenclature—The two species *T. catappa*, Linn. and *T. procera*, Roxb. have been confused in Indian botanical literature. The former is the well known littoral tree which is wild in the lowlands of Malaya and Andamans and, perhaps in the trans-gangetic peninsula; outside India it is found in the Philippines, Molucca, Timor and Seychelles. It has been extensively planted in India from Punjab to Ceylon and Burma from sea-level to 1,000 feet altitude. It often forms a conspicuous feature of the vegetation of sea coast towns like Goa, Madras, Calcutta, Rangoon, Mergui, etc. Its fruit is adapted to dispersal by ocean drift and contains an edible kernel tasting somewhat like those of the almonds, and on this account the tree is known by various names like Indian, Bengal, or Goa almond.

The tree with which the above is being confused, namely, *T. procera*, Roxb. was introduced into the Royal Botanical gardens, Calcutta, by Colonel Kyd in 1794 and is rarely, if at all, planted in India. The ripe fruit of this tree is, like that of the Indian Almond, ellipsoid, smooth and circular in transverse section. Unlike *T. catappa* which is a coastal tree, *T. procera* is an inland tree. It yields an important timber which is called "*bombway*" in the Andamans. Parkinson has described the two species and distinguished them from each other by the following details :—

	T. catappa, Linn.	*T. procera*, Roxb.
Leaf size	8–14 inches by 5–8 inches	5–10 inches by 2–4 inches.
Leaf shape ..	Obovate, tapering down to a small cordate or auricled base.	Narrowly obovate, tapering down wards into the petiole, but not cordate or auricled.
Fruit	Compressed, with two opposite, more or less sharp keels or ridges, $1\frac{1}{2}$–$2\frac{1}{2}$ inches long and almost two-thirds as wide.	Not compressed, $1\frac{1}{4}$ to $1\frac{1}{2}$ inches long and $\frac{3}{4}$ inch diameter.

General description—*Terminalia catappa* is a large, handsome, deciduous tree with a smooth grey bark, whorled branches and large glabrous leaves. It attains a height of 100 feet (Hooker) and a breast height girth of 6 to 10 feet and develops a straight bole, somewhat buttressed at the bottom and fluted above (Fig. 1). The leaves are usually crowded at the ends of branchlets and set on a very short, thick petiole furnished with a gland on either side. Flowers are small and whitish, on slender spikes in the axils of leaves and shorter than them. The spikes carry numerous male flowers and a few hermaphrodite ones towards the base. *Calyx* is glabrous, the tube in the hermaphrodite flowers is rather elongate and contracted above the ovary, villous inside, the lobes being glabrous (Kurz). Kurz distinguishes two

FIG. 1.
Terminalia catappa, Linn. Andamans (Long Island).

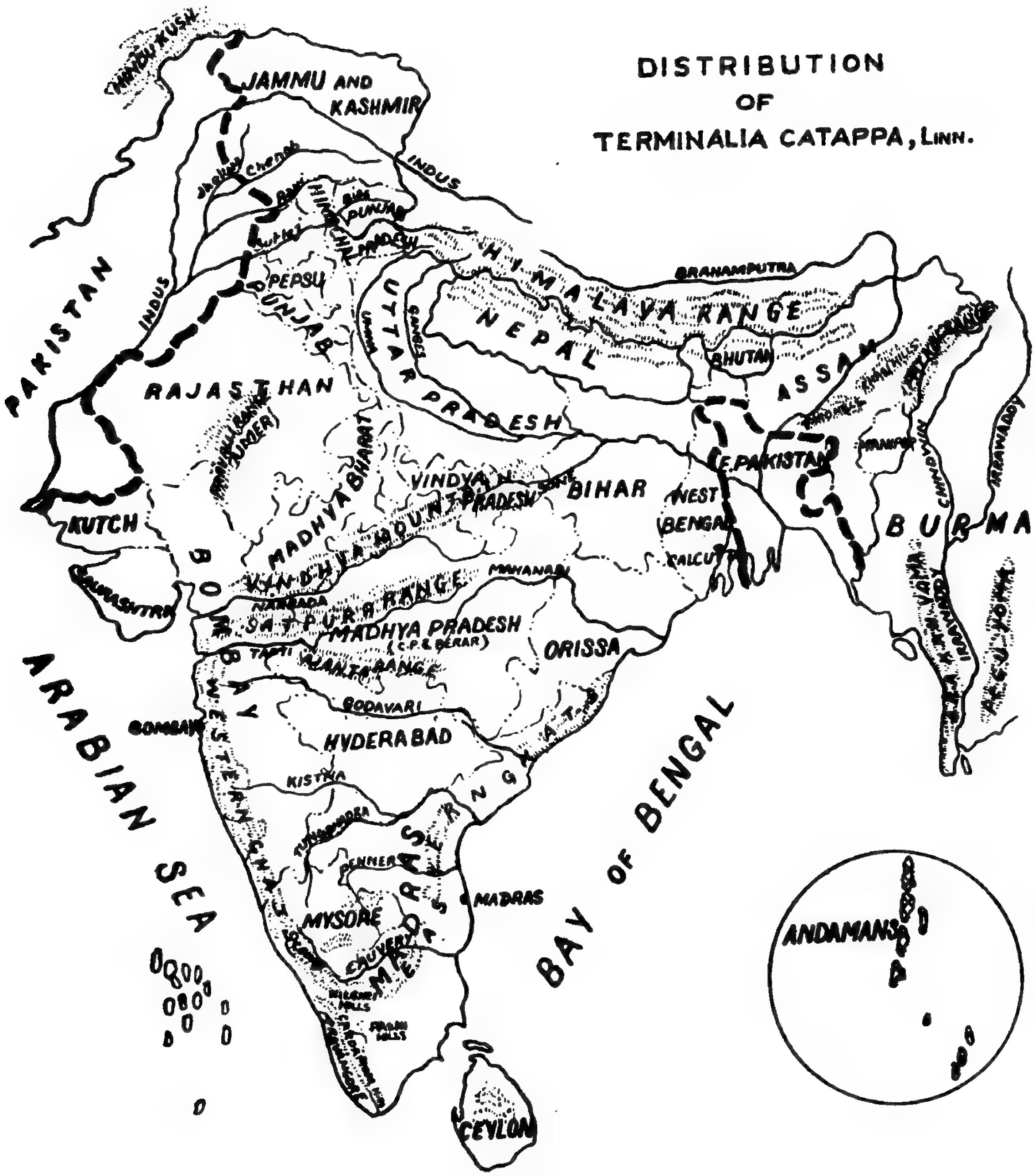
DISTRIBUTION
OF
TERMINALIA CATAPPA, LINN.
JAMMU AND
KASHMIR
INDUS
PAKISTAN
PEPSU
PUNJAB
RAJASTHAN
UTTAR PRADESH
NEPAL
HIMALAYA RANGE
BRAHMAPUTRA
BHUTAN
ASSAM
E.PAKISTAN
MANIPUR
BURMA
BIHAR
WEST
BENGAL
VINDHYA
PRADESH
MADHYA BHARAT
VINDHYA MOUNT
KUTCH
SAURASHTRA
BOMBAY
SATPURA RANGE
MADHYA PRADESH
(C.P. & BERAR)
ORISSA
TAPTI
GODAVARI
HYDERABAD
KISTNA
BOMBAY
MADRAS
MYSORE
ARABIAN SEA
BAY OF BENGAL
CEYLON
ANDAMANS

FIG. 2.

varieties *catappa* and *pubescens* ; the latter has leaves more or less pubescent beneath, while the former is glabrous.

In the Andamans (Fig. 2) the tree is common in the beach forests on the raised sandy beaches above high tide and extends into the forests behind where it is confined to sandy or shingly soils. It also extends to areas not far from the sea where it is invariably confined to sandy soil, or to diluvial deposits formed of detritus brought down by streams and floods (Troup, II, p. 534). The beach forests of the Andamans where the tree has its home, lie just above the high tide and exposed to the full force of the monsoon winds. The predominating and at present the most valuable tree of this forest is the Bullet-wood tree *Mimusops littoralis*. This tree is generally associated with others of minor importance like *Thespesia populnea, Hibiscus tiliaceus, Morinda citrifolia, Erythrina indica, Sterculia* spp., *Pongamia glabra, Gyrocarpus americanus, Calophyllum inophyllum, Terminalia catappa* and *Barringtonia speciosa*. The chief undergrowth is *Pandanus tectorius*. (Working Plan of Andaman Forests, 1936–1966, pp. 9–10).

The tree is very commonly planted in India, in bungalow compounds and gardens, for ornament, and in Burma near villages and monasteries, for ornament and also for the sake of its fruit. Both the fleshy pericarp, which becomes dark red in the cultivated variety of the tree, and the kernel are generally eaten.

Leaf shedding, flowering and fruiting—The leaves turn deep red in autumn before falling. The flowers appear during April–May in Burma, February to May in the Andamans and in various parts of the Deccan, and in October–November in Travancore (Bourdillon). The fruits ripen in June–July or January in Travancore. The fruit is a yellowish drupe with a porous, fibrous to fleshy pericarp and a hard endocarp enclosing the edible seed. The fruit is adopted for disperal by water, the thick husk of porous tissue helping it to float. 22 seeds weigh 1 oz. (Sen Gupta).

Silvicultural characters—The tree is indifferent to light conditions, being able to grow both under moderate shade and in full overhead light. The substratum or soil on which it thrives is permeable siliceous sandstone, consisting typically of the beach detritus brought down by streams and of sand and shingles banked up by wind and the waves. It can be grown on sandy soil and it does best in a moist tropical climate.

Regeneration, natural and artificial—Under favourable conditions the natural reproduction of the tree is satisfactory. On worked soil the fruit germinates and establishes itself readily. The tree is easily raised from seed. Nursery beds sown with ripe seed in June–July give seedlings which will be fit for transplanting a year later, in the next rains.

The tree has been successfully introduced on sandy soil to stop the drifting sand from overwhelming an important drainage channel at Tirumalai – Chambel, Kolundupuram, Tirunelvely district, Madras. (Quarterly Bulletin No. 1, Govt. of India, Central Board of Irrigation, 1941, pp. 11–12).

Utilization – Timber—General characters : Sapwood in young trees greyish and often blotched with yellow on account of a water soluble dye ; in old trees sapwood and heartwood are hardly distinct. The heartwood is light brick red to brownish red, often with irregular lighter and darker belts, lustrous, with rather smooth feel and without characteristic taste or smell. Specific gravity of wood 0·65 (Pearson and Brown). A light to moderately heavy wood the weight varying from 29 to 42 lbs. (Jagadamba Prasad). Anatomically the timber is featured by fairly distinct growth rings. Selected stock is often quite ornamental (Pearson and Brown).

The timber is moderately strong, less so than *T. tomentosa*. It is somewhat refractory to air-seasoning as it has a tendency to develop fine, long splits. The logs should be converted in the green state and the sawn material stacked in shade and protected against hot winds. It has been kiln-seasoned satisfactorily at Dehra Dun. The timber is probably durable under cover. It is fairly easy to saw and work and polishes well.

Uses—The timber is used in house building (posts, beams, scantlings, planking, etc.) yokes, naves, spokes and felloes and general carpentry. It can be classed as good constructional timber, very suitable for rafters, scantlings, posts and beams. Its wavy grain may yield a fairly ornamental plyboard if cut on rotary machine (Pearson and Brown).

The 'Tasar' or 'Katkura' silkworm (*Antheroea paphia*) is fed on the leaves of this tree, among others. The bark and leaves give a black dye (Gamble).

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SCIENCE NOTES

I

Air Layering in Forestry Practice
(a preliminary note)

SUMMARY

This note describes the experimental work on " Air Layering " done at New Forest, Dehra Dun, since 1952. Forty-two common trees species were tried for vegetative propagation by air layers of which 17 were successfully propagated, 8 others were propagated with difficulty and the rest failed to propagate. The details of the method as practised in New Forest are given.

The word "Air Layering" is not very familiar to foresters ; it is much better known to Horticulturists. The vernacular equivalent of the word – namely "Gootie" – is, probably, better known in India. The method of vegetative propagation by air layers is very old. It has been in use in India from early times mainly for propagating fruit trees, and has been adopted in the case of trees which are generally difficult to propagate by ordinary cuttings. Air layers differ from ordinary layers in that, instead of bending down the branch of a tree, which we wish to propagate by layering, to ground level and burying a portion of it in the earth and allowing it to remain in this condition until it strikes root, we take a small ball of wet earth and place it round the branch *in the air*, and secure the mud against drying up or dropping off by covering it with a piece of gunny-sac cloth which in turn is held in position by tying round it some gunny thread (Plate : Fig. 3). This is a typical air layer. During dry weather watering is essential and this can be done by hand, as was done during these experiments, or by hanging a small container filled with water just above the layer. The container has a small hole at the bottom from which water emerges in droplets which fall on the Layer or the water may be conveyed from the hole to the layer below through a wick-like cotton rope which is wound round the layer to secure even distribution of the moisture (Macmillan's Tropical Plants).

After some time – 2 to 4 weeks generally or more – which depends upon the tree species and the prevailing weather conditions – especially humidity and rainfall – tiny white rootlets begin to peep out of the gunny cloth. These are very delicate at first, and are allowed to harden, i.e., set, for a few days – say about a week.

The air layer is then ready to be severed from the parent branch and planted out in shaded nursery beds or in pots which are kept in shade and, if need be, regularly watered until the root system is well established in the soil.

In India, this method of vegetative propagation has not been tried on forest trees on an appreciable scale. The need for research work in this field has not been felt till now because we have not made much headway in the field of tree genetics where air layers can play a very useful part for propagating élite trees which may not breed true to parental characters by sexual methods.

The general object of this investigation was to expand our knowledge on the methods of vegetative propagation of forest trees. Among the special purposes of these investigations which are in progress since the rainy season of 1952, are the following :—

(1) To find out which among our common forest trees can be propagated by means of air layers.

(2) To find the methods of air layering which are suitable for the climatic conditions obtaining in New Forest, Dehra Dun.

(3) To find what media can be used to induce root formation in air layers, and which of these is simple and advantageous in forestry field practice.

and, (4) To ascertain the most favourable season of the year for air layering in New Forest.

1. *Species tried*—Propagation by air layers of 42 tree species was tried in the Research Garden. The work was sometimes repeated on the same species for 3 successive years in order to obtain confirmation of the results.

The following species were tried :—

A. *Broad leaved* :

1. *Acacia arabica*
2. *Acrocarpus fraxinifolius*
3. *Adina cordifolia*
4. *Ailanthus glandulosa*
5. *Aleurites fordii*
6. *Anogeissus pendula*
7. *Bauhinia purpurea*
7a. *Bombax malabaricum*
8. *Bischofia javanica*
9. *Broussonetia papyrifera*
10. *Bursera serrata*
11. *Casuarina equisetifolia*
12. *Casuarina cunninghamiana*
13. *Chickrassia tabularis*
14. *Cedrela toona*
15. *Cinnamomum camphora*
15a. *Dalbergia sissoo*
16. *Eugenia jambolana*
17. *Eugenia operculata*
18. *Gardenia latifolia*
19. *Hibiscus* spp.
20. *Hymenodictyon excelsum*
21. *Kydia calycina*
22. *Lagerstromia flos-reginae*
23. *Markhamia platycalyx*
24. *Melia azedarach*
25. *Morus alba*
26. *Ougeinia dalbergioides*
27. *Platanus orientalis*
28. *Pterospermum acerifolium*
29. *Sapium sebiferum*
30. *Schima wallichii*
31. *Santalum album*
32. *Shorea robusta*
33. *Terminalia myriocarpa*
34. *Terminalia arjuna*
35. *Terminalia chebula*
36. *Tectona grandis*

B. *Conifers* :

1. *Agathis palmerstonii*
2. *Araucaria bidwillii*
3. *Araucaria cunninghamii*
4. *Cupressus torulosa*

From 12 to 25 or more layers were laid down for each species.

The following trees were propagated successfully :—

Casuarina equisetifolia, *Casuarina cunninghamiana*, *Markhamia platycalyx*, *Terminalia arjuna*, *Terminalia myriocarpa*, *Morus alba*, *Hibiscus* spp., *Kydia calycina*, *Broussonetia papyrifera*, *Sapium sebiferum*, *Cedrela toona*, *Bischofia javanica*, *Acrocarpus fraxinifolius*, *Chickrassia tabularis*, *Hymenodictyon excelsum*, *Platanus orientalis*, *Trewia nudiflora*.

Among trees which showed fair promise of success by producing roots in 40 to 50 per cent of the layers, but which did not stand the shock of severing from the parent branch and transplanting except in 10 to 20 per cent of the cases, are the following :

Dalbergia sissoo, *Terminalia chebula*, *Pterospermum acerifolium*, *Bauhinia purpurea*, *Tectona grandis*, *Gardenia latifolia*, *Ailanthus glandulosa*, *Araucaria cunninghamii*.

The remaining 16 tree species failed to propagate by this method.

2. *Methods of layering*—These have been diagrammatically illustrated in the enclosed plate. In brief, they are :—(1) Merely scraping off the outer corky bark down to the inner greenish bark over a length of 1 to 3 inches, and applying a special clay loam constituent or tree moss or a mixture of tree moss and the special clay loam over them.

(2) Cutting out with a sharp knife a narrow ring (about ½ inch wide) of the brown and green barks down to the bast (Plate : Fig. No. 1).

(3) Cutting out a much wider strip of bark down to the bast all round the twig leaving a narrow strip of the bark on one side to protect the bast here (Plate : Fig. No. 4).

(4) Splitting the twig through the middle as shown in the figure (Plate : Fig. No. 7).

Combinations of (1) and (2), (1) and (3) and (1) and (4) were also tried.

From the observation made up-to-date, it has not been possible to establish the relative superiority of these methods, although it may be stated in a broad and general way that method (1) or a combination of the methods (1) and (2) are better than the others.

3. *Media*—The nature of the medium used for completing the air layers is of vital importance to their success. Two media were tried – namely : (i) *a special clay-loam constituent*. This is covered on the air layer with gunny cloth (Plate : Fig. 3). (ii) *Tree moss*. This is covered with waterproof paper (Plate : Fig. 6). The special clay-loam consists of clay, having in it a small proportion of loam of uniform consistency free from grit and dirt, which has been well mixed with about a third of its proportion by volume of compost or well putrified farmyard manure. The two are thoroughly mixed and kneaded with the human soles and allowed to set for 8 to 10 days and kept moist. Tree moss grows on forest trees at high altitudes in places like Chakrata and Mussoorie.

An essential character needed for the medium used should be its hygroscopicity and ability to retain moisture. The advantage which the former medium has is that it is readily available all over the country, while the latter is found only in the hills. The former offers greater resistance to the penetration of the tender roots which grow from the surface of the layered twig, so that such roots are somewhat delayed in emergence (by about 1 to 2 weeks) but it has other distinct advantages namely, that when the sun plays directly on the air layers clay-loam does not dry off so quickly as moss does. During dry weather, however, the clay is likely to contract and cause severe stresses and strains on the delicate roots. With moss, the roots emerge sooner and this is advantageous when rainy period is short.

4. *Season of the year for air layering*—Keeping the air layers constantly moist is one of the essential conditions for success. The appropriate season for this work is therefore the monsoon season, as this is also the season of maximum root development in forest trees. Over the greater portion of India, where the summer monsoon season is the principal rainy season, air layers are best laid down when the monsoon rains have set in. If the rains hold off for more than 2 to 3 consecutive days the air layers will require watering. Under Dehra Dun conditions where the annual rainfall is heavy (85 inches) and humidity does not swerve much from the saturation point during the rainy season, watering of air layers laid down during that season will not be generally required.

Next to moisture, shade is essential for the success of the air layers. Direct sun not only dries off the medium used for the layer but injures the delicate root tips as they peep out of the layers. Best results are therefore obtained in layers which are under full shade throughout the day.

Air layers laid down during the other seasons of the year, especially those prepared during the winter rains, do not succeed unless carefully watered at least once a day, but preferably twice, morning and evening. Heavy failures should be expected in the case of air layers prepared during the dry season.

A good number of forest trees can probably be propagated vegetatively by means of air layers, especially so if the air layers are also treated with root forming harmones like seradix Nos. 1, 2, 3 accordingly as the trees are soft, medium, or hard wooded, respectively. A limited amount of work in this connection is in progress at the Forest Research Institute. It is hoped that this preliminary note will serve to focus attention on this field of research work which is likely to be of far reaching importance in Indian forest tree genetics.

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II

Preliminary note on artificial ripening of the immature fruits of *Broussonetia papyrifera*, Vent. (The Paper Mulberry tree)

SUMMARY

Very little work has been done on the artificial ripening of unripe fruits of forest trees. This note describes the results of treating such fruits of *Broussonetia papyrifera* with Ethylene gas. Both the germinative capacity and vigour of the seeds improved as a result of the treatment.

The wood of the Paper Mulberry tree is a very suitable raw material for the manufacture of newsprint. This tree grows extremely fast under favourable conditions and attains moderate to fairly large sizes and also reproduces itself with great ease in nature, both from seed and coppice.

The information available on the germinative capacity of this tree [I.F.R., Vol. 2(5)] : namely 1% germination, resulted in heavy indents for its seed being placed with the Central Silviculturist ; and it became very difficult to comply with these indents on account of the fact that in New Forest extensive damage is caused to the fruits by monkeys.

The tree bears a reddish, globose, aggregate fruit on which the achenes hang on long fleshy stalks. The attractive colour of the ripe fruits and their palatable fleshy stalks attract birds, monkeys and rodents in large numbers. At New Forest, Dehra Dun, the fruits start ripening late in April or early in May and continue to do so for about 2 months, but the early fruit crop is meagre. The majority of fruits ripen only early in July. Monkeys, which are in abundance on the New Forest estate, in trying to pick up these early fruits, climb to the tips of the fragile branches of this tree which, heavily laden with fruit crop, break under their weight ; thus, thousands of the green, immature fruits fall to the ground or keep hanging dry on the broken branches and thus become useless. To prevent such extensive loss of seed, an attempt was made to artificially ripen the immature seeds with the help of ethylene gas.

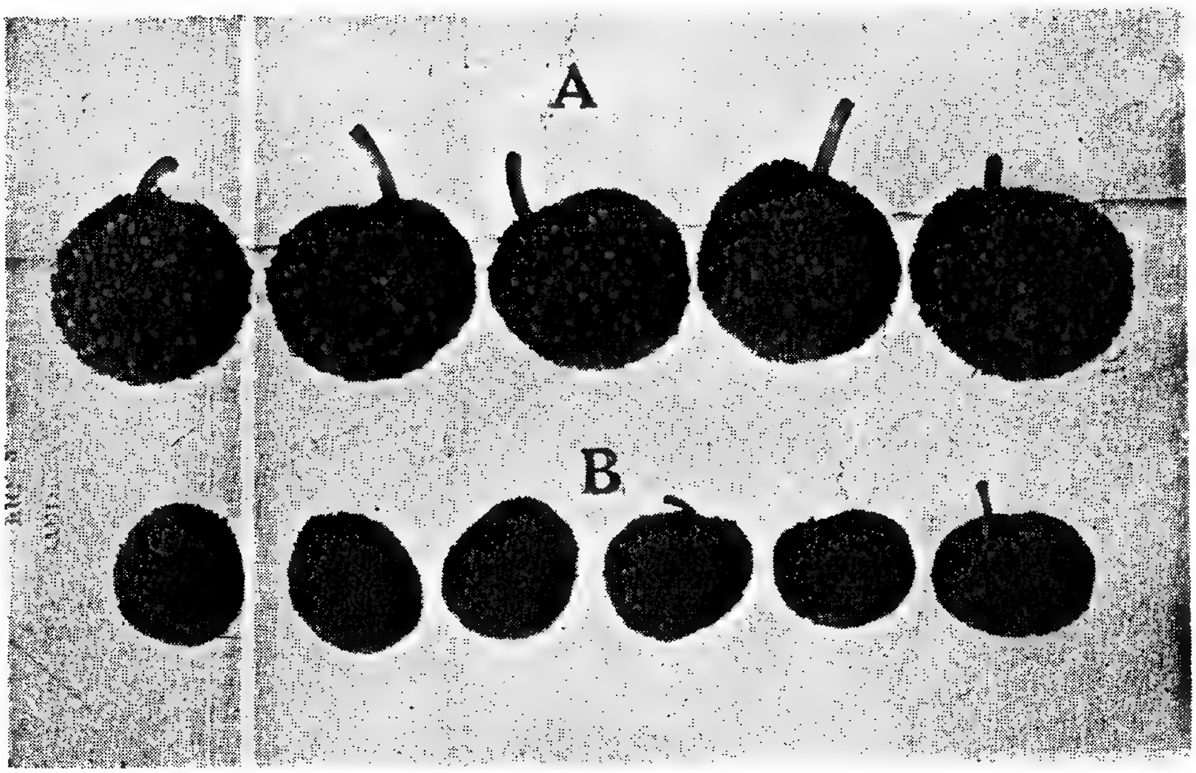

FIG. 1.

Broussonetia papyrifera. Unripe (half-ripe) fruit treated for artificial ripening with Ethylene gas in concentration of 1 cu. ft. of the gas to 1000 cu. ft. of atmospheric air at 65°F. for 48 hours. Treated seeds are marked A and untreated seeds B. The difference in their development is quite marked.

Forest Research Institute, New Forest.

Photo: Rajender Singh, June 1948.

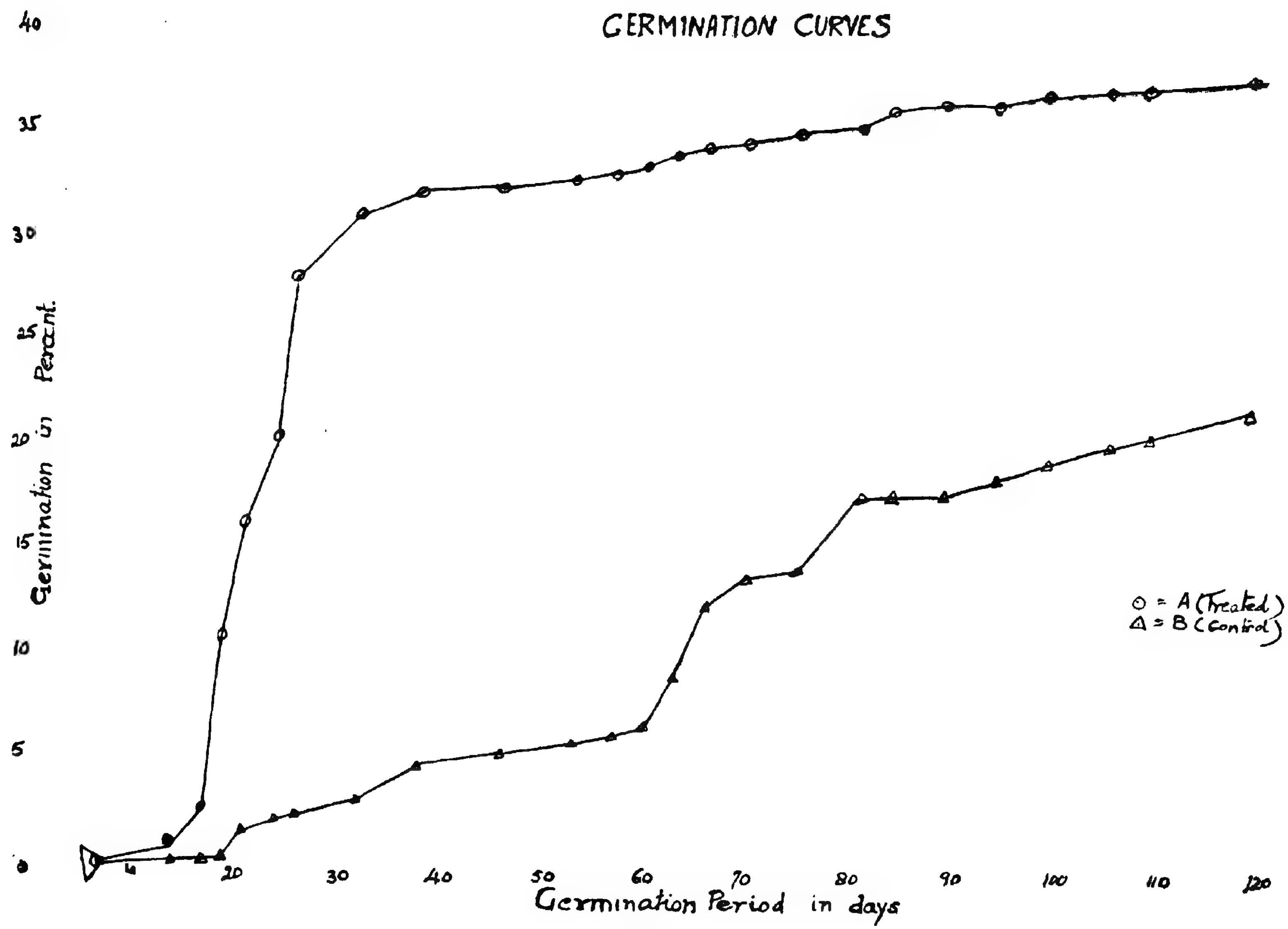
GERMINATION CURVES
Germination in Percent.
0
5
10
15
20
25
30
35
40
Germination Period in days
20
30
40
50
60
70
80
90
100
110
120
○ = A (Treated)
△ = B (Control)

FIG. 2.

Procedure—10 oz. of unripe fruit was taken, well mixed and then divided into two equal parts. One part was kept in a glass jar for 48 hours in a mixture of ethylene gas of 0·1% concentration or 1 c.c. of the gas to 1,000 c.c. atmospheric air, at 65°F. The other part was kept in pure air at the same temperature and for the same length of time. The photographs given below were taken immediately after the above treatment.

The following details were recorded :—

Broussonetia papyrifera : Results of treatment of ethylene gas on unripe fruits

	Treated fruits	Untreated fruits
Average weight of one fruit	85·0 grains	21·7 grains
Colour	Greenish-red	Green
Size	Nearly double that of the untreated fruit	..
Moisture condition ..	Very moist	Dry ; crumbles between the fingers
Seeds	The achenes were quite distinct and separate from one another in the fruit	The achenes remained quite compact and were not separated from one another in the fruit

Seeds from treated and untreated fruits were tested for their germinative capacity with the following results :—

	Treated fruits	Untreated fruits
Average number of seeds per fruit	349	291
Average germinative capacity of seed	37·8%	22·0%

The germination curves for the seeds of treated and untreated fruits is given in Fig. 2.

Conclusions—Ethylene gas has thus proved to be a useful reagent for the after-ripening of immature seed of Paper Mulberry. It would be worthwhile testing the efficacy of the gas for the same purpose on other immature tree seeds. Work in this connection is in progress. This opens out a venue of research which may turn out to be of considerable practical utility in the case of trees whose fruits dehisce on ripening, thus scattering their seed far and wide, so that they are lost if the fruits are allowed to ripen fully on the tree.

The treatment with Ethylene gas is simple, and can be practised without much difficulty even under forest conditions.

It will be seen from the curves that in the case of treated seeds germination commences in about 2 weeks and is practically complete in about 60 days, while in the case of untreated seeds it commences one full week later and takes full four months to complete. The germinative vigour of the former is also comparatively high.

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III

Instances of fusion of the tissues of different trees

Fusion of the parts of different kinds of trees is not so commonly seen in nature. During the writer's forest experience of over a quarter of a century in various forest areas of India, he has come across such instances only twice. The first case was one of fusion of the surface root of a sandal tree with a similar root of *Eugenia jambolana,* the *jamun* tree. Sandal is a well known root parasite, and it is easy, therefore, to comprehend the phenomenon. Probably, at the beginning, a haustorium of the sandal root attached itself to the root of the *jamun,* and for some reason or other the stimulus set up by this attack made the roots of both the trees develop thick calluses at the point of attachment resulting in a complete fusion of their respective tissues. But, what is interesting is not the occurrence of this attachment but the fact that the fruit of the *jamun* tree, when eaten, *had a distinct flavour (or scent) of sandal heartwood.* In fact, it is this flavour which made the writer look for its cause ; and the investigation which followed revealed the fusion which had taken place, of two thick lateral roots, one belonging to each tree.

The second interesting case of such fusion was that between a *Ficus infectoria* and a *Vateria indica* (Figs. 1 and 2). The *Ficus* had apparently *not* started its life on the *Vateria.* The point of attachment was at about half height on the bole of the *Vateria.* But, what was interesting is again not the mere occurrence of such a fusion, but the fact that the *Ficus,* when chopped, emitted the characteristic, aromatic smell of the *Vateria* and, conversely, on chopping its bark the *Vateria* tree exuded a thin milky latex in large quantities. The *Vateria* was an average sized tree in 1938, when the above photographs were made. It was standing alongside the Sagar–Anandapuram road in Mysore State. It was still there when I saw it last in 1949, and it is probably there even now.

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FIG. 1.

A close up of the point of fusion of the *Vateria* with the *Ficus*; observe the thick callus formed at the point of fusion to which both the trees have contributed more or less equally.

Photo: Author, May 1938.

FIG. 2.

Ficus tree fused with a *Vateria indica*; Sagar division, Mysore State.

Photo: Author, May 1938.

SAVE THE LION FROM EXTINCTION

BY M. D. CHATURVEDI, I.F.S.

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When Mahatmaji faced what came to be described as a Socratic trial, for upbraiding the British Lion for "Shaking the Manes", who could in his wildest dream imagine that India herself would choose one day the lion as the symbol of its strength, and the insignia of its greatness. The adoption of the Asoka Lions with the inscription 'The Truth Triumphs', as an emblem of our Independence is the most fitting homage to all that the Mahatma stood for.

Unlike the tiger which probably came to India about the same time as the Aryans did, the lion is the original inhabitant of India. Straggling specimens of this species, which occur along the route taken by Alexander the Great on his homeward march from India through Sindh, Balauchistan, Iran, Mesopatamia and Syria, furnish the land link between the Indian lion and its African cousin.

The fact that the lion does not occur in Ceylon lends weight to the hypothesis that it established itself not until the separation of the island from the mainland. For its connection with the African lion we have to rely, therefore, more on the existing land link than what existed in the Gondwana era when Africa was connected with the Deccan.

We have still to dispose of the doubt which the local name of the island of Ceylon, – *Singhal Dweep*, – casts on our hypothesis. The word *Singhal*, however, does not mean lion as some people imagine, but panther (*Marathi*). As panther occurs freely in Ceylon, its name rightly signifies the island of the panther.

Where precisely in its existing habitat, did lion come to be evolved, is a matter for idle speculation. Naturalists hold the view that the lion came to India from the west. The dice is, however, equally well loaded in favour of the contention that the lion evolved itself in the steppes of the Deccan which supported open jungle and the black buck, providing both food and cover. Nowhere were conditions so conducive in the entire Asiatic corridor for the development of the lion as in the Peninsula. It might just as well be that the Indian lion migrated through the corridor westwards and found a congenial home in the African highlands.

When Sanskrit became the written language of the Aryans in the early stages of their colonization of the *Aryavarta* (*c.* 1,500 B.C.), the lion attracted a great deal of notice and respect. It was referred to in the Vedic literature by a variety of names : *sinha, kesri, hari, mrigendra, mrigripu*, etc. Kalidas, the poet at the Court of Vikramaditya at Ujjain refers in his writings only to the lion ; he makes no mention of the tiger. For his bravery, invincibility, and regal gait, the lion inspired the priest, the poet and the painter alike. The lion was the chosen animal of Lord Vishnu for one of his incarnations (*Narsinha avatar*) and of the Goddess *Kali* as her mount (*vahana*). The lion mounted guard on the Hindu temples, e.g., Jagannath Puri, *Sinhachalam* of Vizianagram ; it was vividly portrayed in the Kushan sculpture of the beginning of the Christian era (Kanaki Tila, Muttra, A.D. 78).

To signify their fearlessness and indomitable courage the proud and the powerful sought to shine in the reflected glory of the lion. Thus, the founder of the Moghul Empire Zahir Uddin Mohammed, assumed the title of Babar (the lion). The Pathan king who drove Humayun away from Delhi and ascended the throne called himself Shersha (the Lion-king). It was the lion which lent fanciful courage to the Kshtryas, the Rajputs, and the Sikhs all of whom styled themselves as *Singhs* (lions).

Up to comparatively recent times, the lion stalked the Indus Plain and the Central Highlands down to the Narbada. In his memoirs, Babar refers to his lion hunts on the banks of the Indus and in the tract which corresponds to the present districts of Banaras and Mirzapur. The chronicles of the reign of Akbar (*Ain-i-Akbari*) and Jehangir, give graphic accounts of lions shot near Lahore and Malwa. The contemporary Moghul paintings at the Indian Museum Calcutta and the Prince of Wales Museum Bombay establish the identity of the animal referred to in the Moghul emperors' shoots as being the lion and dispel any doubts about its being the tiger. Further confirmation is available in the accounts of lion shoots given by Sir Thomas Roe, – the British Ambassador at Jehangir's Court.

The nomenclature employed for the lion and the tiger in Arabic and Persian is confusing in the extreme. It may, however, be safely stated that the word *asad* stood for the lion in Arabic. Thus, we have, Asad-Allah : the Lion of Allah, the name given to Ali, – the Prophet's son-in-law ; Asad-Allah Khan, Ghalib, – the renowned urdu poet. In Persian both *babar* and *sher* stand for the Lion. There is little chance of the word *sher* having been used for the tiger which hardly ever crossed to the west of the Yamuna. What was not known was not named. The Moghul Emperor Babar's emblems 'the Lion and the Mouse' on the gate he rebuilt at Jeruselam and on structures put up by him elsewhere, make it quite improbable for his own title to stand for the tiger. Persian lexicons throw little light on what *babar* stands for. According to the popular version *shere babar* means : maned lion.

In the days gone by, hunting lions was a Royal prerogative ; none, but the Rulers of the land, could kill a lion, not even in self defence. With the discovery of gun powder and the advent of matchlock began the hunting of the lion but in small numbers.

The nineteenth century witnessed the passing of the lion country from the hands of the Sikhs and the Mahrattas to the sway of the East India Company. The arrival of the better armed British on the scene, signalled an unprecedented assault on the lion. What was once a royal privilege, degenerated into wholesale destruction of this noble beast. The lion was treated as vermin to be destroyed like pigs and porcupines. There was usually a price on its head. Every subaltern who could command a rifle, could shoot a lion, without let or hindrance. There were no shooting rules, no close seasons.

Unused to any external danger, the lion in India had established itself as the uncrowned 'King of the Beasts'. In the course of evolution through the ages it had developed scant respect for the power and the prowess of man, and a contemptuous disregard of any danger from other denizens of the forest. It showed little concern for the bow and arrow and less for the sword. Instead, the lion evinced a spirit of reckless defiance passing for its proverbial bravery. Unlike its more spirited striped cousin, – the tiger, – the lion cultivated no cunning, no caution, no finesse. It had no need to. It inhabited the open scrub jungle, – the home of the black buck and the refuge of the decrepit cows supported by the Hindu sentiment.

It was its bravado which proved its undoing. A noisy blusterer, it could not hold its own against the gun. Free of any fear complex, the lion succumbed as much to its own improvidence, as to the advent of the gun. The disappearance of its covert under the stress of an ever mounting pressure of human population led to its further elimination.

The first half of the nineteenth century witnessed the extinction of the lion from its habitat which had covered about a $\frac{1}{4}$th of a million square miles in the preceding century.

In his 'Book of the Tiger' Burton quotes various accounts of lion hunts in the nineteenth century. Of particular interest are the *shikar* incidents in the Hariana tract which covers the existing districts of Rohtak and Hissar, Punjab(I). Captain Mundy (1827) has given thrilling adventures of Colonel Skinner of the Skinner's Horse.

The sporting journals of the time, viz., the *Bengal Sporting Magazine* (1833–41), the *Sporting Review* (1856), the *Oriental Sporting Magazine* (1866), while recounting many a lion hunt, were unanimous in their condemnation of the slaughter of this species which continued all the same unabated.

The lion did not last long in the Punjab. Further south, in Gujerat, Khandesh, Pattan, Baroda, Saugor, Damoh, Palamau, the species persisted up to the fifties of the last century. In the Madhya Pradesh it was known as the *Oontya bagh*, i.e., the tiger with the coat of a camel, which Forsyth believed to be a variety of the tiger !

Lions were shot around Guna until the seventies. The lions imported by the Maharaja of Gwalior from Africa scattered themselves over a vast area. One was shot in the main street of Shergarh (Kotah) in 1922 ; another found its way into the Fisher forest Etawah where it was seen in 1929.

The notion that the Indian lion is different to the African lion is as widely held as it is hotly disputed. There is greater difference between the African and the Indian elephants than there is among the lions. Animals as a rule develop characters as a reflex to their environments, – characters which take thousands of years before getting 'fixed'. Thus, the Bengal tiger is dyed in richer hue than its conferer in the drier tracts of the Madhya Pradesh. Panthers exhibit even greater variation in respect of size, spots and colour within our country than the Indian and African lions do. The country where the lion is found in Africa is not much different to its habitat in India. Consequently, the story about the Indian lion having a paler coat, a smaller mane, and a bushier tail is a figment of imagination deserving little credence. The fanciful distinctions drawn by some sportsmen between the two lions are distinctions without a difference.

The lion is confined to-day only to a small tract in Saurashtra, viz., the Gir Forest covering an area of about 550 square miles. There is nothing peculiar either in the deciduous vegetation of this tract or in its geo-physical character which can provide the slightest clue to the partiality of the lion to this region. Not unlike most protected monuments in our country, the lion owes its existence in this region to the foresight of Lord Curzon, the Governor-General of India at the turn of the century. It was at the instance of Lord Curzon, that the Nawab of Junagadh made the protection of lions in Gir forest, his personal concern. In 1900, the number of lions had dwindled down to about 30, including cubs. Ever since, the greatest precaution has been exercised in the preservation of lions, allowing only a few (3 or 4) to be shot every now and then by high personages as a very special case. Quite a few lions stray far afield into neighbouring territories and pay dearly with their lives for their adventure. The last census carried out in 1950, under the supervision of Wynter-Blyth, placed the number of lions in the Gir forest, Girnar and the Sana Hill at 227. The existing quota of the lions which may be shot per annum under a special permit issued by the Rajpramukh does not exceed four.

Although, the results of the protection afforded to the lion are encouraging, there is grave risk of complacency about the future of the vanishing asset we have in the lion. The question was pointedly raised at the inaugural session of the Indian Board for Wildlife held at Mysore in November, 1952. That the lion is confined to-day only to a small pocket exposed to epidemic and other unforeseen calamities, is a matter which was viewed by the Board with great alarm. It is like having all our eggs in one basket. The Board recommended the development of an additional lion centre in a suitable locality in its former habitat.

The adoption of the lion in the emblem of our Independence, has restored it to its former glory. The implementation of the recommendations of the Board, it is hoped, would rehabilitate the precious heritage we have in the lion, and save it from extinction.

FOREST EDUCATION AND RESEARCH IN INDIA

BY K. L. AGGARWAL, I.F.S.
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Introduction

India is one of the few countries outside Europe whose forests are well-maintained and have now been scientifically managed for almost a century. The credit for this must go to the various forest services of the country, which have a remarkable record of service in remote, inaccessible and often unhealthy surroundings. The training of personnel for these services has remained the special responsibility of the Central Government and now for three decades foresters who guide the destiny of India's forests have almost entirely been trained at the Colleges located in the Forest Research Institute.

The Forest Research Institute at Dehra Dun

The Institute occupies an independent estate called New Forest covering 1,100 acres 4 miles west of Dehra Dun on the Chakrata road under picturesque surroundings at the foot of the Himalayas with the beautiful hill station of Mussoorie in the background. The estate is a detached residential colony and has a high school and an hospital. A demonstration forest, an extensive arboretum and a botanical garden comprise more than half the area of the estate which has been declared as a "reserved forest" under the Indian Forest Act. The imposing main building houses the administrative offices, biological branches, the herbarium, the large museums, the Central Library, the Convocation Hall and the Indian Forest College. The laboratories, workshops and pilot plants connected with forest products research and the Indian Forest Rangers College are scattered over the estate in separate buildings.

It may be pointed out here that the grouping of forest research, forest products research and forest education for both officers and rangers in one central institution has resulted from historical growth. The combination is perhaps a unique arrangement and gives the Institute the character and atmosphere of a forest University – the Alma Mater of the men who work out the destiny of the extensive forests of this great country.

This Institute – one of the foremost organizations of forestry education and research in the world – is under the control of the Ministry of Food and Agriculture of the Government of India and has come to occupy a position of prestige in the technical and scientific world. Since 1951 it has been recognized by the Food and Agriculture Organization of the United Nations as a centre for technical training in forestry for the South-East Asian Region.

History of Forestry Education and Training Courses in Forestry

Sir Dietrich Brandis, the first Inspector General of Forests, immediately after his appointment in 1864, realized that the scientific management of the Indian forests by a properly trained staff was an urgent necessity. On his recommendations, the Government of India in 1867 introduced a system under which the probationers selected for the Superior Forest Posts (afterwards named as Indian Forest Service) were to be trained in Europe.

For training of rangers and foresters a Forest School was set up at Dehra Dun in 1878 by the Government of the then North-West Provinces. This school was taken over by the Central Government in 1884 and was designated as the Imperial Forest College. The present Forest Research Institute and Colleges are outgrowths of this school which now continues under the name of the Indian Forest Ranger College. (Photo 1).

PHOTO No. 1.

PHOTO No. 2.

PHOTO No. 3.

PHOTO No. 4.

This college has by now trained 2,295 forest rangers for the country. Because of the increasing demand for training the Central Government took over the Madras Forest College, Coimbatore in 1948 for training rangers for the southern region of the country – the College at Dehra Dun continuing to serve the needs of the States of northern India. 282 Ranger students have already passed out of the Madras Forest College.

To meet the demand of the expanding forest departments for more officers, a Provincial Forest Service was inaugurated in 1891, the appointments to which were filled by promotion until 1906 when direct recruitment was introduced and a third year added to the 2-year ranger's course. This system of training for probationers of the Provincial Forest Service did not prove satisfactory and was replaced in 1912 by a separate two years course. With this change and as a result of the creation of the research departments (first started in 1906) accommodation in the old school became inadequate ; the gazetted classes and research departments were shifted in 1914 to Chandbagh, an estate nearby in which extensive buildings costing over half a million rupees were erected.

After the first World War the Indian Forest Service was progressively Indianized and the first groups of Indians admitted to the service were trained in British Universities – mostly Oxford. Finally it was realized that the practice and principles of scientific forestry could be adequately demonstrated to the students in Indian forests and in 1926 it was decided to train probationers of the Indian Forest Service, the highest cadre of service in India, also at Dehra Dun instead of in England. Simultaneously it was decided to abolish the Provincial Forest Service Course

In 1932 the Indian Forest Service class had to close down for lack of recruitment resulting from the financial depression prevailing in the country. This state of affairs lasted till 1938, when the Indian Forest College was re-started for training personnel for the gazetted forest services in the provinces and states. It has since been working steadily and has by now trained 433 officers.

Forest Research – Historical

In 1900 the nucleus of the Research Institute was laid by the appointment of a Forest Entomologist and the Forest Research Institute as such came into existence in 1906, as an adjunct to the Imperial Forest College in the same building starting with five branches, viz., Silviculture, Economics, Botany, Entomology and Chemistry. In 1921–22 after the First War it became apparent that the arrangements for forest products research were inadequate to meet the demands made on the Institute ; the Economics branch was largely reorganized and expanded to include well-equipped sections of Wood Working, Paper and Pulp, Wood Seasoning, Wood Preservation, Wood Technology, Timber Testing, and service units of Mechanical Engineering and Wood Workshops.

As the accommodation in Chandbagh to which place the Institute had moved in 1914 was not adequate for its rapidly expanding activities, the beautiful site now occupied by the Institute was bought, in which up-to-date laboratories and workshops were put up, and the imposing main building 350 yards long and covering an area of 7 acres was constructed. (Cover Photo). In 1929 the Institute moved to its present site.

The vital role which the Institute played in defence-research during the Second World War led to further expansion and reorganization. In spite of acute financial stringency in the country a modern plywood plant with slicer, a laboratory and an automatically controlled experimental seasoning kiln, another laboratory and a new paper plant, machinery for the Iron Workshops, the Saw-Mill and the Wood Workshop have been or are being installed

which have brought the Institute more or less to its present proportions. The sections of the Economics branch were raised to the status of independent branches accompanied by further expansion.

All research in the Institute is carried out according to a quinquennial programme. In 1939 the Government of India formed the Central Advisory Board on Forest Utilization for co-ordinating the research programme of the forest products branches with the needs of commerce, industry and the general public. Since 1952 an Executive Committee has been instituted to carry out the work of the Board continuously.

Following is a short resume of the work of the various branches :—

Silviculture Branch

This branch deals with all aspects of silvicultural research and has close relations with the State Silviculturists, supplying them with necessary technical assistance and co-ordinating the results of research. It collects and documents all up-to-date forestry literature from various parts of the world and disseminates this information amongst the States of India as well as to Burma and Ceylon. The branch maintains a silviculture museum (Photo No. 2), a demonstration area and experimental gardens. It carries out experimental studies relating to seed tests, nursery practice, phenology, exotic species and the effects of heredity, in the Institute's own demonstration area and experimental plantations, whereas tree and crop measurements are carried out in a large number of sample plots of which there are as many as 3,000 scattered throughout the length and breadth of the country.

Botany Branch

The main function of the Botany branch is to provide an authoritative technical service to forest officers and botanists in the correct identification of plants. The branch has an excellent herbarium of an ever growing collection of authentic specimens – one of the best in the East. It includes over 1,200 irreplaceable type or co-type specimens representing new genera and species. The branch also interests itself in the collection and distribution of seeds of floral trees and shrubs for experiments all over the world.

Mycology Branch

The Mycology branch specializes in investigations of tree diseases and timber decay caused by fungi with a view to evolving methods of control. Recent work includes studies on diseases of sal (*Shorea robusta*), soil micro-biology with special reference to root diseases of shisham and diseases and decays of conifers and hardwoods. It has a museum of forest pathology and a fine collection of fungi on forest trees and timber. The branch is also one of the centres of the Indian National Committee on Type-cultures of Micro-organisms.

Entomology Branch

Insects constitute one of the principal agents of destruction to forests and forest products. The branch has investigated the life histories of, and devised control measures for, a large number of insects, including the toon shoot borer, the sal borer, the teak and deodar defoliators, etc., and the results were summarized in Beeson's "*Forest Insects*" 1941. A small termite unit has been recently set up for problems of identification and damage. There is also a large entomological museum, an insectary, and a large insect collection of over 20,000 authentically identified species – one of the finest in the East.

Wood Anatomy Branch

Wood anatomy is rightly said to be the foundation of all timber utilization. Not only do the anatomical features of a wood identify it but these enable the Wood Anatomist to classify the various timbers for different uses. The branch carries out anatomical studies on Indian woods to ascertain the various properties of little known timbers and recommend their efficient utilization. At present the branch is engaged on the gigantic task of writing a book on all the Indian timbers. In addition, the branch is engaged on many research problems such as, Indian substitutes for imported timbers. production of gum and resin, and anatomical study of cellulosic raw materials. For the purpose of reference the branch has one of the fines t timber collections in the world as well as a large collection of photomicrographs.

Composite Wood Branch

This branch undertakes to investigate problems connected with plywood, all types of improved wood, and building boards, plastics from wood as also development and testing of modern adhesives. The branch is also engaged in the study of the fundamental factors affecting adhesion and various principles underlying the production of composite wood as also physical and other properties of these various products. (Photo No. 3).

Wood Seasoning Branch

Adoption of correct procedure of seasoning is essential for the efficient utilization of timber. The branch has carried out investigations on the seasoning of important Indian timbers, railway sleepers, poles, bamboos as well as testing, designing and operation of various types of timber seasoning kilns.

The branch has also devised 3-ply solid jute mill bobbins with mango and toon thereby very largely cutting down imports. It has found suitable woods for textile mill bobbins and battery separators and has evolved a treatment for improving the whittling properties of deodar rendering it suitable for making good quality pencils.

Wood Preservation Branch

Research carried out in the Wood Preservation branch proves that the service of the perishable woods can be increased from five to ten times by preservative treatment. Ascu, the well-known water soluable preservative was developed in this branch. It is now engaged on work on the preservation and fire-proofing of thatch and bamboos and has devised a portable plant for giving preservative treatment to green bamboos and light timbers.

Timber Engineering Branch

This branch added only in 1953 prepares economical designs of structures especially those using small dimensioned timber and has recently put up four large halls based on these designs. The branch also investigates the strength properties of these structures.

Timber Mechanics Branch

This branch collects data on strength properties of timbers and other physical characteristics like density and stability of shape, etc., in conformity with international practices and deduces from these data the possible uses to which a timber can be put. It has shown that cheap timbers like mango and *salai* can be used for boxes in place of teak. Recently dynamic tests on Indian timbers have also been included in the programme.

Cellulose and Paper Branch

The manufacture of paper in India from bamboo and *sabai* grass was made possible by the researches conducted at this Institute. Recent work done in this Branch on *bagasse* has been taken up for commercial exploitation for the production of writing and printing papers. (Photo No. 4).

Work has also been carried out on the production of wrapping papers from indigenous timbers.

Minor Forest Products Branch

This branch is engaged in economic research on the numerous minor forest products such as grasses, bamboos, canes, medicinal herbs, essential oils, gums, resins, etc., of which India exports material worth Rupees four hundred millions annually. Among the achievements of the branch may be mentioned the establishment of artemisia and santonin industry in India, cultivation of sarpaganda, researches on improved methods for charcoal manufacture including the designing of a portable kiln and the extraction of camphor from tulsi (*Ocimum kilimandscharicum*). A fine museum of minor forest products is maintained by the branch.

Chemistry of Forest Products Branch

The branch deals with chemical investigations of forest products and the study of the properties and uses of their constituents.

The researches carried out in this branch have resulted in the establishment of a number of industries in the country like production of turpentine and rosin, various essential oils and more recently sizing material for the jute and textile mills from tamarind kernel powder.

Statistical Branch

The Statistical branch helps the research branches and the State Silviculturists in the designing of experiments and analysis and interpretation of experimental data.

Service Branch

This branch is engaged in installing, repairing and maintaining the enitre equipment of the many laboratories of this large Institute, and for this purpose has fully equipped Wood and Iron Workshops.

Publicity and Liaison Branch

The dissemination of the results of the researches carried out at the Institute to the public and the industries is done by this office.. It organizes publications, partakes in exhibitions, sets up showrooms, convenes conferences, conducts visitors to the Institute. In short it does everything possible to increase the technical service of the Institute to the public. Need is being felt for further expanding its activities.

Direct contact and Publications

The officers of the Institute are also in constant touch with other Government departments, Universities, industries – both large scale and cottage, traders, etc., etc. Research facilities are offered at the Institute to University scholars, and apparentices deputed by industrial concerns and State Governments are trained here.

The results of researches carried out in the various branches are published in the Institute's publications as monographs, leaflets, bulletins and records, too numerous to mention.

The *Indian Forester*

Started by Sir William Schlich in 1875 and edited and published by a senior forest officer of the Forest Services of India, the *Indian Forester* is the oldest forestry periodical of the East. It is the technical mouthpiece of the Forest Services of India and one of the main organs of publicity of the research work done at the Forest Research Institute. The Journal's permanent offices are located at the Institute.

Other Publications

The Cellulose and Paper branch issues every quarter Technical Abstracts containing extracts of papers published on pulp, paper and allied subjects for dissemination of important information to the industry.

In addition *Quarterly News Bulletin of the Timber Dryers' and Preservers' Association of India* and *Composite Wood Journal* have started publication. These are edited by the officers of the Institute for the benefit of connected industries and for general information to the public. Though not official, these have the support and backing of the Institute.

THE FORESTS OF AJMER STATE

BY D. P. NAGDEV

Chief Forest Officer, Ajmer

Summary.—**The xerophytic forests of Ajmer State consisting of 46,688 acres lying in the arid zone, comprised about two per cent of the land area till September 1948 when the forest development schemes started functioning under which 67,502 acres more have been reserved to-date. The newly acquired areas are being gradually and systematically improved by adopting various artificial regeneration methods, rotational grazing and rigid protection. Soil conservation and wild-life preservation work is being attended to. The villagers contributing land for formation of forests get the two-third to full of from net forest profits – a most conspicuous and interesting aspect of the administration of the State's forests.**

The State of Ajmer is situated on an elevated plateau which marks the highest point in the plains of Hindustan, while the hills form the dividing watershed of the Indian peninsula. The ancient historic city of Ajmer, with the magnificent heights of Taragarh hills as a background, makes an effective picture even when the hot weather has stripped the hills of their green garb. For this reason an enthusiast has called the Todgarh tract the "Alps of Rajasthan". It was in 1869 when Sir Dietrich Brandis, Inspector-General of Forests, India, first visited these tracts whose forests were being ruthlessly felled and maltreated, that he set proposals on foot to reserve them. In 1874 the Ajmer Forest Regulation (Act VI of 1874) was enacted which empowered the Government to take up any hilly or wasteland to form State forests. This Regulation is four years older than the first Indian Forest Act and it is said to be the first Forest Regulation in India. Within ten years of Sir Dietrich Brandis's first visit about 64,000 acres had been declared as Reserved Forest and brought under forest management.

The forest is mainly xerophytic in type belonging to the subsidiary edaphic type of dry tropical forest (sub-type E-6, *Anogeissus pendula*) as classified by Champion. The more important species composing the forest crop are *Anogeissus pendula*, *Acacia rupestris*, *Boswellia thurifera*, *Prosopis spicigera*, *Acacia leucophloea*, *Acacia arabica*, *Acacia catechu*, *Dichrostachys cinerea*, *Ehretia laevis*, *Lannea grandis*, *Zizyphus nummularia*, *Moringa concanensis* and *Bauhinia racemosa*, mixed with bushes of *Euphorbia nivulia*, *Grewia pilosa* and *ripulifolia*, *Rhus mysorensis*, *Zizyphus jujuba*, etc., forming a sort of under-storey. The other species which come up sparsely include *Anogeissus latifolia*, *Bridelia retusa*, *Dalbergia lanceolaria* and *latifolia*, *Saccopetalum tomentosum*, *Randia dumentorum*, *Albizzia lebbek*, *Diospyros melanoxylon*, *Sterculia urens* and *Wrightia tomentosa*, etc. The charcoal from *Anogeissus pendula* has been considered by the Forest Research Institute, Dehra Dun, to be one of the best of its kind in India.

Up to the year 1938 the area under Reserved forests was 91,148 acres and on 1st April 1938 an area of 44,460 acres was retroceded to Jodhpur and Udaipur States leaving behind only 46,688 acres under Reserved forest for Ajmer State, which forms only about two per cent of the total area of this State. The Planning Commission's report under the Five-Year Plan accepted the principle that the forests in the State should be extended, and the report made a provision of Rs. 10·5 lacs for this purpose. Reservation is now going on but its progress has been very slow. The area included under Reserved forest under the Five-Year Plan is 67,502 acres. Thus the aggregate area under forests forms about seven per cent of the total area of the State.

In the State of Ajmer where famine conditions are very frequent, where the rainfall is erratic varying from 7 to 20 inches per year and where the soil is getting rapidly impoverished and desert conditions are appearing everywhere, every effort is being made to regenerate artificially about 400 acres each year. The following methods are employed for such regeneration :—

Broadcasting

This is done in the plains and in sandy areas. If the soil has a large proportion of clay soil working by ploughing, which costs from Rs. 5/- to Rs. 8/- per acre, becomes necessary.

Dibbling

Seeds of various species are dibbled in *Thor* (*Euphorbia nivulia*) bushes. *Thor* is found chiefly on hill sides and is a good nurse to the developing seedlings. It dies out as soon as the plants have attained sizeable dimensions and overtop it. The method is cheap and costs only Re. 1/- to Rs. 2/- per acre.

***Munj* (*Saccharum munja*) plantations**

Munj is planted only on the sand-dunes, and is a measure taken to bind the sand. This costs from Rs. 14/- to Rs. 20/- per acre depending on the distance from which *Munj* is brought. The planting espacement is 3 by 3 feet to 5 by 5 feet.

Pit and Ridge Sowing

This method of afforestation is suitable for both hilly and plains areas. Pits 1½ feet cube in size are dug. The excavated soil is piled on the lower side of the slope in the form of a ridge. The ridge is 1½ feet long and about 6 to 8 inches high with a bed 6 inches wide on the top on which seed is sown. The pits are half refilled with the weathered soil and seed is sown both in the pits and on the berms. The cost of this method varies from Rs. 12/- to Rs. 14/- per acre, depending upon the soil. The pits are dug at an espacement of 25 by 25 feet.

Trench Sowings

The trenches are made 5 feet long, 2½ feet wide and 1½ feet deep. Half the width of the trench is refilled with loose earth, leaving a drain about 1′–0 wide at the bottom and 2′–0 wide at the top to catch the rain-water. The refilled soil in the trench is made into a sloping bed with a flat surface about 6 to 9 inches in width at the top. The remaining earth is heaped outside the trench in the form of a raised bed about 3 inches away from the edge of the trench, so that a bed about a foot in height and 6 to 9 inches wide at the top is formed. Sowings are carried out at the bottom of the trench and at the top of the bed inside the trench as also half-way and on the top of the raised bed. The cost of plantation formation works out to about Rs. 20/- per acre. The espacement is 25 by 25 feet.

Pot Planting

This method was introduced in the State two years ago. The plants are first raised in nurseries in pots 4 to 5 inches long 3 inches in diameter at the top and 1¾ inches diameter at the base. As soon as the rains have fully set in, the pots are taken to the plantation site. Pits of size 1′–0 to 1′–4″ cube are dug and soil is refilled into them to a depth of 3 to 4 inches. The pot is knocked off, taking care to disturb the roots as little as possible, and the plant with

the soil is then placed in the pit. Earth is then filled up all round so as to leave a depression of 3 inches on the top for accumulating water. The cost of the pots is Rs. 3/12/- per 100, and the labour charges for planting is about Re. 1/- per acre.

Planting Brick method

Bricks made of a mixture in equal proportions of sand, clay and farmyard manure are moulded into a pyramidal shape so that the height of the brick is 1 foot, the top 6 by 6 inches and the base 8 by 8 inches. A hole of about 1 to 2 inches in width and 4 to 6 inches deep is left in the brick to accommodate the pricked-out seedlings. The bricks are dried in shade. The seedlings are placed in the holes of the bricks. Watering of the plants is done after spreading a layer of sand about 1 inch thick on the top of the brick in order to avoid its disintegration. The seedlings are introduced into the bricks in the month of April and the entire bricks with plants in them are planted out at the break of the monsoon. This method has been introduced this year.

Choice of Species

Kumta (*Acacia rupestris*) has proved successful in regenerating hilly and sandy areas. *Prosopis juliflora* does well in the plains and in *usar* and sandy lands. Other species tried are *Ailanthus excelsa* on sandy areas, *Prosopis spicigera, Acacia leucophloea, Butea frondosa* and *Acacia arabica*. The last three species do well in the plains. *Bauhinia racemosa* has proved useful in sandy areas.

Pretreatment of Seed

Prosopis juliflora pods are soaked in water for 48 hours and then spread out in the sun to dry. They are then beaten with wooden posts and then husked. This treatment hastens germination, and the seeds thus treated germinate within 10 to 15 days. Seeds of *Acacia arabica* and *Prosopis spicigera* and others with a hard testa are soaked in water mixed with cowdung for 24 hours and then sown, when they germinate readily.

Rotational Grazing

Grazing is allowed on a rotational system in the old forests. Half the forest area is closed to grazing in any one year. All forest areas are closed to grazing for four months during the rainy season. The incidence of grazing has been fixed at one animal per acre.

The old forests are being managed under the Coppice with Standards system, under a rotation of 40 years. The existing Working Plan was drawn up in 1936 by Coombs and is due to expire in 1955–56. A revised Working Plan has been prepared and sent to the Inspector-General of Forests, India through the Government of Ajmer State for his approval.

The Board of Soil Conservation of Ajmer State has come into existence from 11th February, 1954 and a scheme for forming Shelter Belts has been prepared and accepted by the Ministry of Food and Agriculture, Government of India. The Forest Department maintains the Roadside plantations over a length of 149 miles.

"The Wildlife Protection Act" has been revised in order to give better protection to the dumb and mute creatures which have often been killed mercilessly. In addition the

Afforested sand-dunes. (Ajmer State).

Trench-sowing of *Prosopis juliflora* in Bibichilla Forest. Age 5 years. (Ajmer State).

Planting bricks with plants for planting during the ensuing monsoon season. (Ajmer State).

"Dadolia Sanctuary" which has an area of 132 acres has been established to protect the Wildlife of the State.

The most conspicuous and interesting aspect of the forests of Ajmer State is that the Forest Department is merely a custodian of the forests which belong to the people. Since the lands have been constituted as Reserved forests under Regulation IV of 1874 and I of 1892, the original owners are entitled to two-thirds or the entire share respectively of the nett revenue derived from the forests. In addition certain other rights have also been given to the villagers, the chief of which is the right to cut and remove grass free of charge which, in practice, means that practically the whole of the grass crop goes to the right holders of the *Shamlat* and *Jagir* forest areas.

FORESTRY IN THE ANDAMAN AND NICOBAR ISLANDS

BY J. BANERJI, I.F.S.

Chief Conservator of Forests, Andaman and Nicobar Islands

Summary.—With an area of 3,107 sq. miles distributed over about 183 islands in the Bay of Bengal, the Andaman and Nicobar Islands have an equable climate with high rainfall. While the settlement was established in 1788 the Forest Department has been operating since 1883. Departmental operation has been the keynote of exploitation, and valuable timbers like Padauk, Gurjan and Silvergrey found purchasers from an early date. After the islands were taken over from the Japanese in 1945, a large 8 feet Band Saw-mill has been set up with a potential capacity of 50,000 tons. At present about 58,000 tons are extracted annually. The Indian demands for 'Matchwoods' and 'Plywoods' are satisfactorily met ; surplus timber is exported to U.K., U.S.A. and other foreign countries. North Andamans forests have been leased out for 25 years. Treated Mangrove poles are exported to the mainland. Recently about 569 refugee families have been settled on 2,845 acres of cleared agricultural land inside the forests. The natural regeneration methods of these tropical rain forests have been satisfactorily solved by the "Canopy-lifting, Shelterwood system" of the Andamans. When the *full silvicultural yield of 150,000 tons is exploited, during the Second Five-Year Plan of India,* the annual revenue is likely to be Rs. 200 lacs, against about Rs. 60 lacs now.

Situation

The Andaman and Nicobar Islands, consisting of about 183 islands in the Bay of Bengal, have a total land area of approximately 3,107 sq. miles. Except for a few centrally situated large islands, all the others are small and un-inhabited. They are situated at a distance of about 590 miles from the mouth of the Hooghly, 120 miles from Cape Negrais of Burma, and 91 miles from Pulo Brasse, off Achinhead, in Sumatra. Forests in the Nicobar group, which comprises of 20 islands, have not so far been exploited. The total population of the Andaman and Nicobar Islands is only 31,000 or 10 per sq. mile.

2. Climate

The main islands in the Andamans group consist of ranges of low hills usually not more than 1,000 feet high, enclosing long, narrow, and winding valleys. Most of the streams are ephemeral. The mean annual rainfall varies between 120 and 80 inches, decreasing from south to north. The mean annual temperature is 75° F. with a daily variation of 20° F. Climate is equable throughout the year with no pronounced summer or winter. The islands receive profuse rains from both the South-West and North-East Monsoons. Except for three months in the year, February to April, rainfall is well distributed throughout the year.

3. Early History

Due to their position across the ancient trade routes of Bay of Bengal, the Andamans drew early attention of the pioneer navigators. Marco Polo in 1286 A.D. reported that these islands were inhabited by cannibals. This tradition is still current though it is incorrect. There are no doubt a few indigenous wild tribes, like the Jarawas, Sentinelees, Ongees and Andamanees, who used to be hostile to all civilized approach ; now, however, they are friendly, except for the first two.

4. Settlement

The first settlement was founded by Lieut. Blair in 1788, but remained neglected till 1857, when Dr. Mouat re-established Port Blair, the present capital (population 12,000). The main reason for establishing the settlement was to found a penal colony where the convicts were paid a living wage, and were virtually free.

5. Area of Forest

Table I shows the area of forests and population of the different regions in the Andaman and Nicobar Islands :

TABLE I

Area Statement

Locality	Region	Population	area (sq. miles)	Forests (sq. miles)	Percentage
Andamans Group (163 islands)	Port Blair Settlement	12,000	120	..	..
	North, Middle and South Andamans Forest Divisions	5,000	2,352	2,331*	..
TOTAL :		17,000	2,472	2,331	94%
Nicobars Group (20 islands)	Car Nicobar Island	10,000	49	NA	..
	The other 19 islands	4,000	586	NA	..
TOTAL :		14,000	635	535†	..
GRAND TOTAL :		31,000	3,107	2,866	92%

NA = Not available.
* = Omitting 9 islands under foreign lands group and Barren and Narcondam islands.
† = Rough estimate.

Excluding Port Blair Settlement, and Car Nicobar Island, where there are reasonable concentrations of population, the rest of the area is a long stretch of forests with no villages. All the forests in the Andamans have been declared Reserve Forests by the Government. There has been no Forest Settlement in the Nicobars, though the islands are known to contain valuable forests.

6. Early History of the Forest Department

Almost from the beginning of the Settlement in 1858, the Government have worked the valuable forests by Departmental Agency. A start was made with a portable Forest Saw-mill, handsawing of the sleepers in the forests, and extraction of *Padauk* (*Pterocarpus dalbergioides*) poles for the Indian Telegraph Department. Later, a Saw-mill was erected by the Public Works Department with an average outturn of 100 tons monthly. The Forest Department was started in 1883 when the first Forest Officer Mr. Ferrars was appointed ; he had only about a dozen elephants to feed the small Saw-mill. In 1915, this Mill was closed, and a new Mill was bought by the Forest Department from Messrs. The Bombay Burma Trading Company Ltd., with a possible monthly output of 750 tons in squares and scantlings. A second Mill, an American Circular Mill, was erected in Chatham in 1927. An American Band Mill was opened in North Andamans in 1925, but was closed down in 1930 due to trade depression. Extraction was done mainly by elephants, logging railways, rafts, and coastal crafts. When a market for "Matchwoods" was developed about 1925, buffalo was used successfully for dragging. Mechanical extraction by means of skidder was tried in 1930 ; but it was soon discontinued owing to the general trade depression.

7. Japanese occupation

The islands were under the occupation of Japan from March 23rd, 1942 till it was taken over by the British on October 7th, 1945. After independence these islands were given the status of a Part 'D' State under a Chief Commissioner. The Department is now administered by a Chief Conservator of Forests with 5 Divisions, each under a Class I Officer, and 2 minor Divisions, under Class II Officers.

8. Forest Types

The climatic climax types of forests in the Andamans are primarily Tropical Wet Evergreen, or Tropical Moist Deciduous, with subsidiary edaphic variants. The structure and floristics follow the same general patterns of tropical rain forests. The more important types are briefly described below :—

(i) *Tidal forests*—These are developed on saline alluvium fringing all the muddy creeks, within the zone inundated daily by tidal waters. The first line consists of *Rhizophora mucronata* and *conjugata* ; higher up pure stands of *Bruguiera gymnorhiza* 80 feet high are frequent.

(ii) *Littoral forests*—These are influenced by, but out of the reach of, the sea, occupying flat strips of sandy beach along the coast varying from a few yards to several chains in width. The important species are *Mimusops littoralis*, *Gyrocarpus americanus*, *Pongamia glabra* and *Terminalia catappa*.

(iii) *Alluvial Semi-Evergreen*—This type is developed on well-drained alluvial banks of rivers, usually above the level of flood waters. It can be immediately recognized by the presence of giant stems of *Dipterocarpus incanus*, associated with *Sterculia alata* and *Anthocephalus cadamba*. It is a climatic climax on the riverain soil.

(iv) *Foothill moist deciduous*—This type is found girdling the base of hills up to about 300 feet. Species in upper two canopies are mostly deciduous, while the undergrowth is evergreen. The predominant species are *Padauk* (*Pterocarpus dalbergioides*), *White Chuglam* (*Terminalia bialata*), and *White Dhup* (*Canarium euphyllum*). This is a stable pre-climax on the dry foothills.

The President of the Indian Union at the green chain of the Government Saw-mills, Andamans, watching conveyor chains for disposal of Saw-mill refuse—11th March 1954.

(v) *Low-level evergreen*—Above the foothill moist deciduous, the slopes are covered with this climax type dominated by magnificent trees of *Dipterocarpus griffithii*, and *Dipterocarpus turbinatus*, and *Planchonia andamanica*. A local edaphic variant of this type is dominated by almost gregarious *Dipterocarpus kerrii* in an area of about 100 square miles.

(vi) *High-level evergreen*—Above the low-level evergreen at an elevation of 1000 feet and above, on steep windswept slopes, where the soil is shallow the trees become stunted. The predominant species are *Dipterocarpus costatus* and *Canarium manii*. This type is not commercially important.

9. Artificial Regeneration

Since 1883 various methods, both artificial and natural, were tried to raise plantations of valuable species – at first of *Padauk* (*Pterocarpus dalbergioides*) and *teak* (which is an exotic), and later *Gurjan* (*Dipterocarpus* spp.) and *White Chuglam* (*Terminalia bialata*) ; later, mixtures of teak, Padauk, *Pyinma* (*Lagerstroemia hypoleuca*), *Albizzia* spp. and *Eucalyptus* were tried. After extraction of fuel, the vegetation was cut and burnt by cheap convict labour ; seeds were then dibbled, or sown broadcast, on well burnt patches. The total area of plantations thus raised from 1883 to 1939 was 5,046 acres. Large areas of these plantations proved unsuccessful. The cost of formation, with the abolition of convict labour, became unremunerative. Artificial regeneration was therefore stopped since 1939. Small plantations of teak have again been made in 1954 from stumps.

10. Natural Regeneration

The first attempt of natural regeneration in these forests were made in 1911 by clearing round *Padauk* seed bearers, and freeing the seedlings and saplings in gaps ; these proved a failure. About the years 1931 to 1934, natural regeneration methods of the tropical evergreen, moist deciduous, and riverain forests were successfully established by Shri B. S. Chengapa (trained at Dehra Dun) by judicious manipulation of the canopy during the first three years of regeneration. Since then, the method has been developed, and improved considerably in technique ; now annually about 3,000 acres are regenerated under the "Canopy-lifting Shelter-wood System" of the Andamans. The essence of the system is as follows :—After removal of all valuable species of exploitable girth, about 4 to 5 seed bearers are left per acre, and the highest possible un-interrupted upper canopy is formed of the existing trees. The undergrowth is cut ; in deciduous areas the debris is burnt in situ in early April. As the regeneration appears, the seedlings are carefully weeded and tended ; the upper canopy is removed by girdling in stages within a year or two. A considerable portion of the new crop consists of advance growth of temporarily shade-tolerant evergreen species, already available on the ground before felling, which shoot up as soon as sufficient light is allowed. The total area regenerated so far, under the "Canopy-lifting Shelter-wood System" is about 20,000 acres. Failure have been few.

11. Silvicultural Problem

As the new crop consists of a mixture of fast and slow growing tropical broadleaved softwoods and hardwoods, most of which are light-demanders after the establishment stage, it is not yet fully known how to tend and thin the new crop, consistent with the silvicultural needs of the different species. The fastgrowing softwoods will need a rotation half that of the slowgrowing hardwoods. It is not yet fully understood how a two-rotation crop of light-demanders intimately mixed in the same area should be dealt with at different stages, and

regenerated naturally after the first rotation. The present indications are that the new crop should be established separately in groups early in its life as :

(1) prominently Gurjan
(2) ,, Padauk
(3) ,, Softwoods.

12. Working Plan

Though a Working Plan was completed in 1952 for about 1,829 square miles of forests in North, Middle, and South Andaman Divisions, its prescriptions could not be brought fully into operation due to the compulsory Colonization fellings which started in 1953. The prescriptions are being partly followed in the North and the South Andaman Divisions, with considerable deviations for obtaining a balanced outturn for the market. Though the Working Plans are not strictly followed in exploitation, no felling is permitted without adequate provision for the natural regeneration of the annual coupe.

13. Wildlife

Wild animal life is peculiarly deficient throughout the Andamans. The deficiency is pronounced specially as regards mammals of which there are only 20 identified species, of which again, about 12 are peculiar to these islands. The large mammals and monkeys are entirely absent from the Andamans ; bats and rats constitute nearly three-fourths of the known mammals. The small pig (*Sus andamanensis*) is an invaluable source of food for the aboriginees. The paucity of animal life appears inconsistent with the theory advanced by Kurz that the islands were once connected with the mainland ; on the contrary it shows that the Andamans were separated by sea from the mainland before the Triassic age. The Andamans species of mammals and birds differ significantly from those of the adjacent Nicobar Islands, Sumatra, Java, etc. *Sambhar*, barking deer, hog deer, and spotted deer were introduced early in the century and have now multiplied to an alarming extent. Amongst birds the Andaman green pigeon, hawk-eagle, scarlet minivet, black headed *bulbul*, white headed *mynah*, the Indian cuckoo, Andaman paroquet are common. The cotton teal, the whistling teal, and the common teal are occasionally found locally. The adjacent waters are full of fish of many varieties, and are infested with Hammer-headed sharks.

14. Matchwoods

About the year 1930, some of the tropical broadleaved "Softwoods" of Andamans, like *Papita* (*Sterculia campanulata*), *Didu* (*Bombax insigne*) and *White Dhup* (*Canarium euphyllum*) were found suitable for the manufacture of Match splints and Match boxes for which only *Aspen* was considered satisfactory in the past. Extraction of these "Matchwoods" was soon organized, and Andamans now supply annually about 12,000 tons to the Match Industry at Port Blair, Calcutta and Madras, out of the total annual requirement of about 90,000 tons by the whole Match Industry in India. As the natural regeneration of 'Matchwoods' offers no problem, the future supply is assured.

15. Plywoods

India needs about 5·5 millions tea-chests every year for export of tea. As some of the Andamans species, like Gurjan (*Dipterocarpus* spp.), *White Chuglam* (*Terminalia bialata*), *Badam* (*Terminalia procera*) etc., called "Plywoods", were found acceptable for tea-chests, a Plywood Industry for manufacture of tea-chests, dependent upon Andamans timber, was

developed at Calcutta since 1945. Consequently about 10,000 tons of 'Plywoods' are earmarked for the Industry. Due to a slump in the Tea Industry, the demand for 'Plywoods' has gone down considerably since 1953, and there is now surplus output of 'Plywoods' in the Andamans.

16. Oriental Woods

Species like *Padauk* (*Pterocarpus dalbergioides*), *Silvergrey* (*Terminalia bialata*) and *Marblewood* (*Disospyros oocarpa*), producing pleasing ornamental woods are a special feature of Andamans. Though the quantity available is small, these species are highly prized in Indian and Foreign markets, and fetch a handsome price.

17. Mangrove Poles

The total area of tidal mangrove forests is approximately 84 square miles, about a fourth of which is covered with a dense crop of *Bruguiera gymnorhiza* considered suitable for Telegraph, Telephone, and Power Line poles. Recently these poles are being treated with creosote by open tank process, and supplied to various authorities in India. The absorption is about 4 lbs. c. ft. It has been found that for *Bruguiera*, pressure treatment is not much better than open tank treatment, and the difference in absorption is negligible. At present Andamans can supply 6,000 treated poles a year.

18. Saw-mills

At the time of evacuation in March 1942, the Saw-mills at Chatham were left intact, but they suffered heavy damages due to subsequent bombing by the Allies. On re-occupation the old Circular Mill was re-assembled with a 7 feet head-rig. In addition a new Bandmill with 8 feet and 54 inches head-rigs, 60 inches resaw, two rip-saws, and an edger has been set up and put into operation recently. The Saw-mills are handling about 30,000 tons in a year, and are perhaps the largest in India, and one of the foremost in South and South East Asia. When in full production they are expected to handle about 50,000 tons annually.

19. North Andaman Lease

The forests of North Andamans were given out on a 25 years' lease to Messrs. P. C. Ray & Co. (India) Ltd., on 31st August 1951. They will extract 75,000 tons a year and will put up a Saw-mill, a Plywood Factory, a Seasoning Kiln, and a Timber Treatment Plant. They pay royalty as a fixed percentage of the market value of timber.

20. Colonization

Under the First Five-Year Plan, the Government of India sanctioned a Colonization Scheme for the settlement and rehabilitation of 4,000 refugee families of East Pakistan and others in the Andamans. This Scheme contemplates clearfelling, and making ready for the plough, 20,000 acres of flat land for paddy at 5 acres per family. The whole work, including construction of permanent houses for the refugees, has devolved upon the Forest Department. Work was started in January 1953, and the progress since is as follows :—

(*a*)	Land cleared and allotted for cultivation	..	2,845 acres
(*b*)	Number of families settled	..	569
(*c*)	Number of houses built	..	90
(*d*)	Number of temporary huts built	..	50
(*e*)	New logging railways laid	..	28 miles

21. Financial Results

Except for the forests of North Andamans, which have been given out on lease, all exploitation in the South and Middle Andamans is done departmentally. Transportation is done with the help of elephants, tractors with logging arches, logging railways (24 lb. × 30 inches gauge), rafting, and coastal crafts. Matchwoods and plywoods are exported as logs to Madras and Calcutta. Hardwoods and ornamental species are sawn in the Chatham Saw-mills, and exported as lumber to Calcutta, Madras and foreign countries like U.K., Holland, U.S.A., Iraq, Iran and Australia.

Table II shows the results of exploitation in recent years :—

TABLE II

Government Exploitation in the Andamans

Year	Extraction (tons)	Exported to mainland (tons)	Exported to foreign countries (tons)	Sold locally (tons)	Revenue (in lacs of Rs.)	Profit according to commercial accounts (in lacs of Rs.)
1946–47	33,558	11,437	..	1,451	18·21	NA
1947–48	34,488	24,587	..	3,300	39·73	NA
1948–49	47,741	31,009	..	4,009	52·48	+ 9·42
1949–50	48,634	36,520	..	5,090	70·23	+ 9·73
1950–51	41,801	26,923	..	4,961	52·59	+ 7·90
1951–52	45,933	33,090	..	4,969	74·35	+ 8·29
1952–53	37,647	25,108	..	4,650	61·16	+ 7·79
1953–54	43,487	20,458	4,057	4,560	NA	NA
1954–55 (Up to August 1954)	22,508	8,096	1,908	2,285		

NA = Not available.

While the estimated annual yield of the forests according to the Working Plan is 150,000 tons a year, at present only about 55,000 tons are extracted between the Government and Messrs. P. C. Ray & Co. (India) Ltd. It is estimated that when the full silvicultural yield is sold in the market, the gross annual revenue will be about Rs. 2·0 crores, instead of about Rs. 60 lacs to-day. It is estimated that about 15 million tons of mature timber are now ready in the forests for exploitation and the demand for timber in the Indian and Foreign markets is high, it is expected that full production will be achieved within the period of the second Five-Years Plan of India.

THE ANDHRA FORESTS

BY A. A. KHAN, I.F.S.
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Summary.—The Andhra forests extend over a total area of 13,172 sq. miles. The two main types met with are the dry-deciduous and the dry-evergreen. The ex-*panchayat* and the ex-*zamindari* forests which have been taken over by the Forest Department are in a most degraded state and strenuous efforts are being made to rehabilitate them by modern methods of silviculture.

The main silvicultural problem facing the Forest Department is the successful raising of coastal casuarina to achieve which many experiments are under progress.

The fauna has been mostly destroyed due to indiscriminate shooting.

I. Historical perspective and organization of the Forest Department

The State of Andhra was formed on the 1st October, 1953. Prior to this it formed part of Madras State.

The forests of Andhra formed part of the ancient forests of "Dandaka", where the early scenes of the Ramayana are believed to have been laid. Very little is known of their history till the year 1765, when the British came into possession.

In the year 1856, Dr. H. F. C. Cleghorn, M.A., Assistant Surgeon, was deputed by the Government of Madras to report on the forest wealth of the Presidency. It was after Dr. Cleghorn's report, that real efforts were made for the introduction of forest conservancy and protection. Inspite of the measures introduced for conserving the forests, promiscuous cutting of the forests continued. Exploitation was on the licence system, under which indiscriminate felling of valuable timber trees, specially Red Sanders (*Pterocarpus santalinus*), was permitted anywhere in the forest provided a seigniorage fee of a nominal nature was paid for the timber removed. Wood for building, agricultural and domestic purposes was allowed to local *ryots* free of tax. Thus the forests received little protection and the operations were mainly confined to the realization of revenue.

In 1881, Dr. Brandis (later on Sir Deitrich Brandis) was instructed by the Government of India to proceed to Madras and consider the whole subject of forest conservancy in that Presidency. After an extensive tour in Nellore, Cuddapah, Bellary and Ananthapur Districts, Brandis advised the Government on its future forest policy and drew attention to the fact that grazing, fire, indiscriminate cutting and shifting cultivation practised by the hill tribes were ruining the forests. He recommended the introduction of a Forest Act and the sanctioning of reservation of large compact blocks of forest. In pursuance of this recommendation the Madras Forest Act was passed in the year 1882, and this Act which is still in force is the first forest law enacted for the Presidency. Soon after the promulgation of this Act the question of formation of forest reserves in the various districts engaged the serious attention of the Government of Madras.

In pursuance of the recommendations of the Forest Committee of 1912, reserve forests, which must be preserved for climatic purposes, or for the protection of water sources, or which were valuable as producers of timber or fuel, were retained under the management of the Forest Department, and all other forests, which were mainly useful for grazing, the protection of which, owing to their being close to cultivated land lead to constant friction with the

villagers and which were not likely to repay the time and money spent on their improvement were gradually handed over to Forest *Panchayats* (Village Committees) for management and control. Thus, about 1,975 square miles of reserved forests in the present Andhra State were given up by the Department. Unfortunately these were so ruthlessly exploited and many of which were so badly devastated that they were rendered fit only for quarrying. The Government therefore reverted their control to the Forest Department in 1947. The problem of reafforestation of such denuded areas and improvement of their quality has now to be tackled by the Forest Department ; it is engaging their serious attention.

Similarly, on the promulgation of the Madras Estates (Abolition and Conversion into *Ryotwari*) Act of 1948, large tracts of private forests, which had suffered worse fate than the *panchayat* forests have been taken over by the Department, but as these forest areas are over-burdened with many rights and privileges, recognized or unauthorized. The administration of ex-*Zamindari* forests has been one of forbearance, and we are obliged to connive at irregularities which would not be tolerated in other forest areas, lest we involve ourselves in petty revolts with the subversive elements who are ready to take advantage of any stituation.

In order to place the forest administration upon a satisfactory footing, the first step taken after the report of Sir Deitrich Brandis in 1881 was to increase both the superior and subordinate forest establishment. Prior to this the forest staff of the Presidency consisted of 1 Conservator, 15 Deputy and Assistant Conservators and a limited subordinate staff, as a large section of the wooded area, mostly in the plains and close to villages, was under the management and control of the Revenue officials under the head "Madras Jungle Conservancy". After Sir Deitrich Brandis's report it was realized for the first time that there must be a District Forest Officer in each Revenue (Civil) District and that the District Forest Officer should work under the control of the Collector. The Conservator had merely to forward all his views to the Collector. The Conservator was the adviser to Government and was responsible for the efficiency of the staff, for technical matters and financial results. The Conservator also controlled the appointment, posting and promotion of Forest Rangers and Foresters.

The Forest Department was under the control of the Board of Revenue until May, 1919 when it was transferred to the control of the Chief Conservator of Forests.

II. Brief summary of forest types and forest resources

The principal forest tracts of the Andhra lie between 13° and 19° North latitudes and 77° and 85° East longitudes. Broadly speaking, the forest tracts may be divided into two zones, namely, the Eastern and the Western.

The Eastern zone comprises of the entire forest areas covering the agencies, in the Revenue districts of East Godavari, Visakhapatnam and Srikakulam, chiefly confined to the uplands north of the Godavari River. The forests in this zone are of two main types, viz.,

1. Tropical dry-deciduous forests, and
2. Tidal forests (littoral forests on estuarine mud).

The dry-deciduous forests present considerable diversity in composition and quality and can be described as an associate formation of mixed deciduous species of low density, poor girth and height, except in small patches where growth is much better. The principal natural factors determining the floristic composition are its distribution due to variation in altitude, which ranges from about 250 to 5,300 feet above sea-level, and the variation in rainfall (30 to 60 inches). The common trees are *Chloroxylon swietenia, Anogeissus latifolia, Erythroxylon monogynum, Terminalia tomentosa, Pterocarpus marsupium, Adina cordifolia, Xylia xylocarpa* and *Lagerstroemia* mixed with bamboos. Teak is rare and is confined to a small area in the Agency.

The tidal forests are situated on heavy alluvial deposits at the mouth of the Godavari and the left bank of the Upputeru. They are composed of several littoral species and are commonly referred to as mangrove forests. The important trees found here are *Avicennia* sp. *Sonneratia apetala*, *Rhizophora mucronata*, *Ceriops roxburghiana*, *Aegiceras corniculatum*, *Lumnitzera racemosa*, *Exoecaria agallocha*, and the weed *Suaeda maritima*.

The western zone comprises of the hills (Palmaner) in Chittur District, which form the eastern tongue of the large plateau of Mysore and the five important hill ranges of Seshachallams, Palakondas, Veligondas, Lankamalais and the Nallamalais. The Palmaner plateau with the general elevation of 3,000 feet (the highest peak being 4,200 feet at Horsely konda) is so different from the rest of the area for soil, climate, and other conditions that it forms a unit by itself. The average elevation of the rest of the country may safely be taken as 2,000 feet, some of the highest peaks being Veerakonda (3,088 feet) in Kurnool District and Papanasam (2,800 feet) on the Seshachallam plateau.

The climate and rainfall vary considerably from healthy and bracing in the Palmaner plateau to hot and oppressive in Cuddapah. South-west monsoon (June–September) is the chief source of water supply, while the north-east monsoon (October–November) also yields a fair quantity, the average rainfall varying from under 20 inches in Ananthapur and Chittor Districts to 35 inches in Cuddapah and Kurnool, except in Nallamalais where the average is 50 inches.

The following main forest types can be recognized in the State :—

(1) The dry-deciduous forests.

(2) The dry evergreens.

The dry-deciduous forests vary considerably in condition, composition and density. The most valuable tree found in the hill forests of Cuddapah is Red Sanders (*Pterocarpus santalinus*). In the terai forests, near the outer edge of the hill slopes, a low type of thorny growth containing *Acacias*, *Albizzias* and *Prosopis spicigera* are generally met with. The other species that occur as one proceeds into the interior are *Hardwickia* sp., *Anogeissus* sp., *Pterocarpus marsupium*, *Terminalia tomentosa*, *Chloroxylon swietenia*. Teak is not common in these forests, except in the Nallamalais of Kurnool where it occurs mixed with bamboos.

The dry evergreen forests lie inland between the coast and the hills in the dry district of Nellore. This district which has a very dry climate is comparatively bare with an average rainfall of about 20 inches. The area is covered with evergreen shrubs, which, if protected, grow into a thick almost impenetrable jungle in which fires do not enter. Of the dry evergreen scrub, the most characteristic species are *Memecylon edule*, *Maba buxifolia*, *Hugonia mystax*, *Hemicyclia sepiaria*, *Mimusops hexandra*, *Aegle marmelos*, *Canthium didymum*, *Pterospermum suberifolium*, *Vitex altissima*, mixed with inferior shrubs such as *Ochna squarrosa*, *Flacourtia ramontchii*, *Carissa carandus*, *Ixora parviflora*, *Zizyphus oenoplia*, *Toddalia aculeata* and *Gymnosporia montana*.

The Agency tracts and the interior of Nallamalais are a comparatively unopened country where tree growth is fairly well preserved on account of their inaccessibility. They carry a fine stand of *Xylia* which can be profitably converted into railway sleepers. Bamboos are available in large quantities. The forests are rich in other minor forest produce, like *Adda* leaves, Tamarind, Soapnut, Grasses for fodder and thatching, honey, wax, etc.

The mineral wealth of the Andhra forests is no less than its forest wealth. Iron ore, Coal, Chromite, Manganese, Bauxite, Barites occur in varying quantities.

III. Forest Area

The tabular statement below furnishes the statistics relating to the area of forests under the control of the Forest Department and their legal status. Statistics are wanting in respect of the private forests.

Total land area of the State	Area of forests under the control of the Forest Department				Percentage of forest area to land area
	Reserved forests	Reserved lands	Ex-*Zamindari* forests not declared as reserved lands	Total area of the forests	
	(square miles)				
64,543	9,720	941	2,511	13,172	24%

The aim is to increase the over-all forest area to a minimum of $33\frac{1}{3}\%$ but no definite programme to achieve this end has yet been formulated.

IV. Regeneration – natural and artificial

Natural regeneration in the forests of Andhra State, except in mangrove forests, is mainly by coppice. In the mangrove forests, the regeneration is mainly by the seed.

The plantations formed are mainly of teak and casuarina. The clear-felling of suitable natural forests and conversion into teak areas is done on a small scale, the total area under such plantations being 17 square miles. In the coastal areas which are suitable for raising casuarina, a total area of 16 square miles is under casuarina plantations, the system adopted being clear-felling and planting casuarina on a 9-year rotation.

V. Silvicultural problems and silvicultural research

The most important silvicultural problem relates to casuarina plantations. Of the nearly 16,000 acres of coastal forests included under casuarina planting scheme, only about 10,500 acres are now in the planting programme, the remaining areas having been for the present given up as unsuitable due to past failures. Research is being carried out to ascertain the reasons which contribute to these failures and the measures to be taken to raise casuarina plantations successfully in these areas.

Samples of soils and sub-soils drawn from depths of 0″–6″, 6″–12″, 12″–18″, and 18″–24″ from the good areas (where casuarina has thrived well) and bad soils (where casuarina has been a failure) were got analysed. The results indicate that the good soil, especially the top 6 inches layer is richer in organic matter, nitrogen and calcium than the poor soil, that the water retention capacity of the first 6 inches layer of good soil is double that of the bad soil, and that bad soils are slightly more acidic than good soils. From this, it has been concluded that it would probably be necessary to increase artificially the organic content of the bad soils to improve the water retention capacity and biological activity and to add critical quantities of Lime and Phosphorus, which are to be decided by laying out a series of properly replicated research plots.

It was found that casuarina plants that were rich in nodular growth on the roots had not only a better initial growth but also the subsequent increment was more spectacular than

those with poor nodular growth. Further, dead casuarina trees in the plantations showed the absence of root nodules. These nodules are supposed to fix atmospheric nitrogen and enrich the soil. The possibility of inducing nodule formation in transplanted seedlings in soils where early mortality of casuarina has been significant, by artificial inoculum, was investigated. This gave rise to two problems, viz., source of inoculum and whether the nodules-inducing inoculum was present in soils where the plantations failed. The cultures of bacteria and fungus were isolated from fresh nodules and maintained on mannitol-Cango-red medium and 2% malt extract agar, respectively and two pot experiments were conducted. The following conclusions were drawn from the experiments :—

1. The inoculation of the soil with bacterial suspension, fungus suspension or mixture of the two suspensions has no effect in promoting the growth of root nodules. The addition of air-dry powdered nodules promotes the formation of root nodules and development of more vigorous seedlings.

2. The source of inoculum to induce root nodules in poor soil is as much potential as that in good soil. Therefore, the failure of casuarina in poor soil does not appear to be due to the absence of nodules but to other factors.

Another nursery experiment to study the formation of root nodules in good and poor soils of Sriharikota Island (Nellore District) has also just been undertaken. Observations will be made on nodule formation in different layers of good and poor soils (top 1 foot soil, 1–2 feet soil, 2–3 feet soil and mixture of 0–3 feet soil) at intervals of 3 months for 18 months from the start of the experiment.

The rotation for casuarina plantations (which were planted at 7 feet × 7 feet in the past and are now done at $8\frac{1}{2}$ feet × $8\frac{1}{2}$ feet and 7 feet × 7 feet on 50 : 50 basis for the purpose of experimental study) has been prescribed in the Working Plans varying from 7 to 10 years without any basis for the same. With a view to arrive at the best rotation, experimental plots in the 1946 plantations in Nellore District have been laid out in 1953. The results of the experiment will be known only in 1958 when the data of growth and increment in volume and weight at the different ages will be available for fixing the best rotation for casuarina plantations.

VI. Working Plans

The position with regard to working plans is as follows :—

Area for which working plans have been completed and sanctioned ..	4,888	sq. miles
Area for which working plans have been completed but not sanctioned	2,213	,,
Area for which working plans are being compiled	1,946	,,
Area for which preparation or revision of working plans has to be taken up	4,125	,,

At present, two Working Plan Officers of the rank of Assistant Conservators with the necessary staff are engaged on the preparation of working plans in two forest divisions. The preparation or revision of the working plans of the other divisions would be taken up by these officers in the order of priority.

VII. Extension and farm-forestry, etc.

Along the Kurnool–Cuddapah canal, *babul* plantations have been successfully raised. Along the Hagari River, a shelter belt of *Prosopis julifora* has been successfully raised to prevent sand drifting into cultivated lands.

The afforestation programme now being implemented includes the introduction of important fodder trees which can be utilized in times of famine and other emergencies.

VIII. Production, marketting and utilization

The ideal followed is to exploit all produce through the agency of contractors, departmental extraction being undertaken in exceptional cases only. The forests are worked on the general principle of sustained yield and no special marketting arrangements exist as the products are generally consumed locally. The needs of the public for small timber, fuel and bamboos and grazing are adequately met under the present system.

The Andhra Paper Mills at Rajahmundry which is owned and worked by the State Government requires about 8 lacs of bamboos which are supplied through the agency of a contractor from the bamboo coupes in the upper reaches of the Godavari and the bamboos are floated down the river to Rajahmundry.

IX. Soil Conservation

Soil erosion has not attained serious proportions in the Andhra State and hence no soil conservation measures on any large scale have been undertaken. But in the tribal or agency areas, which cover nearly 5,000 square miles, shifting cultivation presents a potential source of soil erosion, which, if not checked, is likely to lead to serious erosion in the near future. There are two types of shifting cultivation, locally called *Podu*, viz., the ordinary or '*Chilaka Podu*' on flat ground and the hill or '*Konda Podu*'. The latter is very destructive.

The control of shifting cultivation in these areas presents a difficult and yet unsolved problem, as the aboriginals resent any interference with their mode of living. Restrictions imposed in the past to control it have been simply ignored by the aboriginals as they have no assets to pay towards any punitive measures. The problem is of such far reaching importance that the Government is now considering the total prohibition of shifting cultivation at least on hill slopes and ridges.

X. Wildlife

With the extension of cultivation, progressive destruction of forests and uncontrolled *shikar*, big game has almost disappeared except in the interior agency tracts and the Nallamalais. Except spotted deer and *sambhar* other fauna is very scarce. Proposals are under the active consideration of the Department to form one or two regular game sanctuaries.

FORESTRY IN ASSAM

BY P. D. STRACEY, I.F.S.
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Past History

Assam was the last of the Indian Provinces, or States as they are now called, to be annexed by the British. The country had remained independent until 1826 under the Ahoms, a Shan race who had ruled in Assam from the thirteenth century A.D., when they entered the country from Upper Burma. Internal dissensions led to the occupation of the country by the Burmese for a short period early in the 18th century, but their rule was terminated by a British expeditionary force in 1824–25, and by 1842 the Assam Valley was completely under British occupation. The Surma Valley, forming part of Bengal, had, however, been under British rule from a much earlier date.

The organization of the Forest Department in Bengal and Assam, which together formed what was known at the time as the "Lower Provinces", started in 1862, after Brandis, the first Inspector-General of Forests to the Government of India, had toured through a part of the area. Dr. Anderson, the then Superintendent of the Botanical Gardens, Calcutta, was appointed temporarily as Conservator of Forests of the "Lower Provinces" in addition to his own duties in 1864, and he compiled a report on the forests of the Surma Valley in 1864 and Dr. Gustav Mann, a German and the first Assistant Conservator of Forests, did the same for the Assam Valley Forests in 1868–70.

Assam's separate identity commenced with the initial separation of the country from Bengal under a Chief Commissioner in 1874, followed by it's re-amalgamation with part of Bengal in 1905 as "Eastern Bengal and Assam", and it's final emergence as a separate Governor's Province in 1912. The Forest Department came into being in 1874–75 with a Deputy Conservator in charge, and a Conservator was appointed in 1879. Control of fellings in the Unclassified State Forests was transferred from the Civil authorities to the Forest Department in 1883, and the Assam Forest Regulation replaced the Indian Forest Act in 1891. As it was decided that the Forest Officers should be the assistants of the Deputy Commissioners of Districts, the Divisional charges were arranged to coincide with Districts. The early classification of Major and Minor Divisions, the former being the main timber Divisions at the time, has disappeared with the development of the different forest areas.

At the time of Dr. Anderson's charge the forests were extensive in area but were being worked intensively only in the neighbourhood of floatable rivers, particularly in the districts of Sylhet, Cachar, Goalpara and Kamrup from where logs could be floated to Bengal. Production of Sal sleepers commenced with the pushing of the railway system into Assam early in the 1900's. The timber-trade was, however, much less developed in the Assam (Brahmaputra) Valley than in the Surma Valley, and in Upper Assam timber-exploitation and clearance of forests came only with the advent of tea-cultivation in 1834. Along with this and in the Lakhimpur District in particular, exploitation of forests both by hand-sawing and saw-mills took place, mainly for production of *Simul* shooks for tea-boxes, a trade which was wiped out by the introduction of the 3-ply tea chest into Assam 30 years ago, and for bridge, sleeper, and constructional timber. Exploitation was inevitably along the sides of rivers and roads, as the latter were developed. The best lands having been given for tea-cultivation, the

Reserved Forests were naturally pushed into the interior, and at present they mainly occupy the fringes of the foot-hills on either side of the Valley, with tea-gardens and rice cultivation occupying the flatter, more fertile sites.

Forestry in Assam may be said to have passed through two phases before the present one – the first which lasted up to about 1925, was one of consolidation of the forest estate by reservations, boundary demarcations, road construction, etc. ; the second phase which lasted up to the end of the 2nd World War in 1945, was characterized by the beginnings of Silvicultural research, of the intensification of Working Plans and of the real start of plantation and natural regeneration on a large scale, and culminated in the heavy exploitation of the War years ; the present or post-war stage is one of intensive development of communications to tap interior areas and of plantations to replace the heavy fellings of the war, together with attempts to introduce forest industries aimed at greater utilization of the available forest products and at solving the problems created by the partition of India, which brought in great difficulties of export and loss of markets.

Forest Types

Within it's comparatively small area Assam presents considerable diversity in it's forests. The main vegetation is of a climatic-climax type, though biotic and edaphic factors have also played their part, mainly in Upper and Central Assam where extensive tracts, now covered by forests, were once part of the flourishing Cachari kingdom which was wiped out by the Burmese invaders.

Assam's location between Latitude 22° and 30° North and Longitude 90° and 96° East, gives it's climate an essentially temperate character, while the generally heavy rainfall, ranging from 160 inches in Upper Assam to 60 inches in the lowest rainfall belt of Central Assam, gives it's flora an essentially tropical touch. Indeed it is this unusual combination of temperate climate with a rainfall of tropical intensity which renders the flora of Assam so interesting.

The main types of forests, commencing from the lower end of the Brahmaputra Valley may be summarized as follows :—

1. The Sal (*Shorea robusta*) forests of Goalpara, Garo Hills, Kamrup, Darrang and Nowgong, forming the natural extension of the Sal belt that runs at the base of the Himalayas in the U.P., Bihar, Nepal and Bengal. These sal forests have been classified by Champion into 3 main and several sub-types and are, generally speaking, Moist Sal Forests, with rainfall varying from 74 inches in Nowgong to 153 inches in Goalpara. Local variation in quality depending on drainage, soil, and moisture occur, the best quality being found in the Garo Hills and in the *bhabar* areas of Goalpara West, which approach All-India Quality Class II.

The sal forests of Assam are managed on rotations of 150 years under either the Uniform System with Improvement fellings in the plains areas or the Selection System in the Hill areas. Natural regeneration is more readily obtained in the drier, well-drained forests and depends on adequate admittance of light with a judicious control of undergrowth conditions. Fire and grazing play an important part in the question of regenerating these forests, it being generally observed that controlled fires which bring about drier undergrowth conditions, and controlled grazing which assists seedlings, are helpful. In the absence of grazing, shrub-cutting is most helpful. In fact this operation as also forced burning of undergrowth is a *sine qua non* of Sal regeneration technique in Assam.

Natural regeneration has, however, generally not kept pace with fellings except in the Kamrup Division and recourse has had to be taken to line-sowings to supplement existing reproduction and to permit of yield-removals.

2. The *Bonsum-Amari* (*Phoebe hainesiana-Amoora wallichi*) forests of central Assam occupy parts of the Darrang District on the North bank where it is of a moister type, and parts of the Nowgong, and Sibsagar Districts, and the plains portions of the Naga Hills District on the South bank where it is of a drier type. The main associates are *Chickrassia tabularis* and *Tetrameles nudiflora*, the latter being a tree of great size forming a deciduous emergent layer to the main semi-deciduous forests. The undergrowth is generally of a rather impenetrable nature characterized by the thorny climbers *Acacia, Mezoneurum, Zizyphus, Uncaria,* etc.

The two main species *Bonsum* and *Amari* are valuable furniture and constructional timbers respectively. As exploitation in these forests has been on a selection basis for many years without much thought for the reproduction of the main species, their regeneration, both being shade-bearers and both having large seeds of a short dispersal range, presents an interesting problem. On the South bank compensatory plantations of these, and other species in accessible areas has been the vogue, but there are sufficient indications that they can be regenerated under moderately close canopy conditions if assisted by weedings and tendings, though the rather poor incidence of mother trees in certain areas and the short seed dispersal range would necessitate supplementing with transplants. In the main *Bonsum-Amari* forests found in Darrang sowings, and subsequently transplants, of *Bonsum* in lines have been done with success after the main fellings have been completed and middle-canopy and valuless trees removed by felling or girdled.

3. The *Nahor-Hollong* (*Mesua ferrea-Dipterocarpus macrocarpus*) forests of Upper Assam.—These are the unique evergreen climatic-climax forests of Upper Assam and may be termed *temperate rain-forests,* characterized as they are by a region of heavy rainfall and a generally cool climate. They occupy the foot-hills of the Naga Hills and the adjoining plains areas in the districts of Sibsagar and Lakhimpur, and present the typical three-storied appearance of tropical forests, with an emergent layer of *Hollong,* which on the higher ridges is replaced by *Makai* (*Shorea assamica*), with *Nahor* in the middle storey, and a lower storey mainly of cane and *Geruga-Tamul* (*Pinnanga gracilis*).

Nahor, or the "Iron-wood of Assam", a handsome evergreen tree of moderate size, is an intense shade-bearer and forms a natural understorey to it's main associate, *Hollong,* a tree of magnificent height and appearance with a clear bole which sometimes reaches 100 feet. *Hollong* is one of the main veneer species of Assam and has, during the past thirty years or so, completely overshadowed it's associate *Nahor,* which was once the more esteemed tree for posts, bridge-piles, sleepers and even for constructional timber, as a result of the development of the veneer industry for tea chests in Assam. During the last twenty years *Hollong* sleepers pressure treated with creosote and crude oil have gradually established themselves, and this permits of a very complete utilization of the *Hollong* tree. *Sam* (*Artocarpus chaplasha*), *Seleng* (*Sapium bacatum*), *Hingori* (*Castanopsis*), *Morhal* (*Vatica lancaefolia*), *Outenga* (*Dillenia indica*), *Gonseroi* (*Cinnamomum cecicodaphne*), *Jutuli* (*Altingia excelsa*) and several species of Magnolias are the main associates of *Hollong* and *Nahor.*

As the two main species regenerate freely under natural conditions, *Hollong* being able to tolerate fairly heavy shade in the early stages but thereafter demanding full overhead light, while *Nahor* is a natural shade-bearer, their management which is under the so-called Selection System with regeneration-tending presents no difficulties. The rotation age for

Hollong and *Makai* is 180 years by which age a tree of 7½ feet breast-height girth should be available. Of the two other species which are utilized for sleepers after treatment with creosote and crude oil under pressure *Cham* (*Artocarpus chaplasha*) regenerates freely but *Jutuli* (*Altingia excelsa*) is the opposite.

4. The *Hollock* (*Terminalia myriocarpa*) forests of Sadiya.—This very characteristic forest type is found in the upper reaches of the Brahmaputra and it's tributaries and is more or less confined to the Sadiya Division and the Tirap Frontier Tract. The main species is a tall handsome semi-deciduous tree, and associated with it are *Simul* (*Salmalia malabarica*), *Khokon* (*Duabanga sonneratioides*), *Bhola* (*Morus laevigata*), *Kadam* (*Anthocephalus kadamba*), etc. *Hollock* is the main structural and furniture timber of Upper Assam and is also a very useful veneer species. It regenerates profusely in flooded areas, favouring fine soils generally but dislikes clayey soils. It's natural regeneration is, however, generally of a fortutious nature and as it presents no difficulty in being artificially regenerated by sowing, this is the system adopted. The Silvicultural system is Selection *cum* Improvement fellings with girth limits on a cycle of 30 years and a rotation age of 75 years by which time a 7½-foot girth tree may be expected, and compensatory plantations.

The forests of the Surma Valley are rather different to those of the Assam or Brahmaputra Valley. Several species of equal importance and distribution go to make up the forests, the most important being *Gurjan* (*Dipterocarpus turbinatus*), *Sundi* (*Alceodaphne owdenii*), *Panisaj* (*Terminalia myriocarpa*), *Nageswar* (*Mesua ferrea*), *Cham* (*Artocarpus chaplasha*), *Korol* (*Kayea floribunda*), *Hotia* (*Chikrassia tabularis*), etc. The undergrowth is generally cane and bamboo, the latter predominating on raised ground. Regeneration of certain species is plentiful, but as the forests have been creamed by girth-limit fellings for many years, stocking of the main species is poor and the prospects of regenerating them naturally are remote. The forests are managed under Selection fellings to girth-limits, with artificial regeneration in the shape of Compensatory plantations in accessible areas.

Besides the reserves of sal timber in Lower Assam, of veneer timbers like *Hollong* and *Hollock* in Upper Assam, of softwoods like *Bombax* found universally but more plentifully in the riverain areas of Upper Assam, of hardwoods like *Chikrassia tabularis*, *Amoora wallichi*, *Phoebe hainesiana*, *Morus lavevigata*, *Cinnamomum cecicodaphne*, *Artocarpus chaplasha*, *Magnolia* species, etc., found either in certain well defined localities or generally distributed, all of which are readily saleable, Assam's forests contain a large number of species which may be described as non-durable hardwoods, most of which are at present unsaleable. In addition there are vast reserves of bamboos, reeds and grasses sufficient to sustain several paper mills ; of canes which are extracted and sold for basket-making, both locally and after export, and for house building, of elephants, of medicinal and commercial plants and products, etc.

Area of Forests

Assam from the air appears to be almost entirely covered by forests, and indeed if the tea garden and agricultural lands are excluded there is very little land which is bare of jungle of some sort. This, however, is rather a misleading picture, for though the proportion of forest area in general to the total land area of the State works out at 47·14%, a very large proportion of this, as will be seen from the statement below, is taken up by the Unclassified State Forests. These are literally *lands at the disposal of the Government* and in the plains are wasting assets in that they are rapidly coming under settlement, while in the hills they include the *jhum*-lands of the tribal people, which under the Indian Constitution are vested entirely with the Tribal District Councils. The real position is that only a little over 12% of the State area is under permanent forests of any kind at present, and it is not

likely that the target of 25% will ever be attained unless large areas, at present subjected to shifting-cultivation in the hills, are turned over for permanent forests.

Statement showing forest areas in Assam, 1952–53

Total area of State	Forest areas			Proportion of forest area to State area		Remarks
	Reserved	Protected	U.S.F.	Reserved and Protected forest only	Total forests	
sq. miles	sq. miles	sq. miles	sq. miles	%	%	
51,467 (excluding N.E.F.A.)	6,362	109	17,888	12·56	47·14	1. Area figures for Private and Communal forest are not available. 2. The area of *Zamindari* forest is about 600 sq. miles.

Regeneration

The status of natural regeneration in Assam has been briefly dealt with under the various forest types in the preceding paragraphs, and it is not proposed to elaborate more except to say that, generally speaking, solutions to the problems of obtaining natural regeneration of most of the valuable species have still to be found, except in the case of the *Nahor-Hollong* forests of Upper Assam, where natural regeneration is presenting no difficulties, and to a certain extent in the case of Sal.

At the same time it must be stated that the poor representation of certain valuable species in some forests, particularly of Central Assam and Cachar, makes it extremely doubtful if they can be ever regenerated naturally, and unless a demand can be created for the many non-saleable species available regeneration of these forests by natural means will not prove economical.

The first experimental plantations of Sal and miscellaneous species were formed in several Divisions, apart from the early teak, and rubber plantations of the 1880's which for reasons of economy were abandoned, only in 1925. The technique in these early plantations was naturally tentative, but their lessons have been of great use. At present the custom is line seed-sowings for most species except of course teak and *Bonsum*. Spacing has been standardized to 4 × 8 feet for sown species and 6 × 6 feet for stump planting of teak, *Ajhar*, etc., with the exception of *taungyas* where they vary from 10 to 14 feet.

The most interesting experiments have been with mixtures but it was soon realized that mixtures of fast and slow-growers inevitably condemned the latter to suppression, while intimate mixtures presented difficult problems of thinnings. A compromise has therefore, been achieved by retaining pure sown lines as a general practice with insistence on adequate nursery stocks of any species for in-fillings.

The extra-ordinary luxuriant weedgrowth in a country of heavy rainfall such as Assam necessitates the securing of establishment as soon as possible. This is generally achieved within 3 to 5 years by such expedients as wide lines, the sowing of cover crops like *Tephrosia candida* between the plant lines, and early but controlled thinnings in which edge-stems are never cut, etc. Attempts are being made to replace departmental plantations with *taungyas* wherever possible, as in the former type of plantations costs are rather high because of high labour rates, failures, and heavy weed conditions.

Plantation work in Assam has made great strides during the past 25 years and progress is at the rate of 3 to 4 sq. miles per annum while the introduction of plantation schemes and standardized techniques, together with the insistence on maintenance of plantation forms and journals, has served to systematize the work.

Silviculture

The year 1927 marked the beginnings of systematic silvicultural reasearch in Assam with the appointment of Rowbotham as Silviculturist. In 1930 Assam Forest Bulletin No. I on "Nursery, Plantation and Regeneration Notes" was brought out by him and revised by R. N. De in 1939. The Silviculturist had no field staff of his own until 1946 and all work of laying out and maintaining sample and experimental plots had to be done through the Divisional Staff, an unsatisfactory arrangement. The Silviculturist's post was held in abeyance for 16 years after the retirement in 1930 of Rowbotham and was made permanent only in 1946. A post of Botanical Forest Officer was created in 1913 and the two posts were and are held by the same incumbent.

A number of Sample and Experimental plots had been laid out before the war, but almost all of these were neglected during the war-period and had to be abandoned, and new plots were opened from 1946.

Continuity of research and administrative control with a gradually expanding staff has been a feature of post-war years and steady progress has been made, all Silvicultural experiments being based on standardized methods with proper replication and randomization. A large number of experiments on artificial regeneration methods have been carried out and as many as 42 Sample Plots, including 18 old plots, now exist. Plantation thinning research experiments have been initiated, an important item as all thinnings in plantations at present are empirical in nature. The collection of data for Standard Volume and Commercial Out-turn Tables has been commenced, the only publication in the past of the latter nature having been Purkayastha's Growth and Volume Tables for certain species.

A certain amount of research on the cultivation of medicinal and economic plants had been conducted in the past and the initial (1943) experimental Cinchona plantations were laid out by the Silviculturist. A Preliminary List of Medicinal Plants has been published and work on these lines has been stepped up in the post-war period. Recently two schemes, one commercial and the other a research scheme under the I.C.A.R. have been embarked upon for some medicinal plants.

In addition a commercial scheme of wattle plantations in the Khasi Hills has been started, the growth of this species having been found to be exceptionally good.

Progress on the completion of the Flora of Assam has not been possible owing mainly to pre-occupation with Silvicultural Research, but a scheme for publishing the remaining part of the flora on Monocots and at the same time of revising the whole Flora on Dicots has been prepared.

Hollong-Nahor Natural Regeneration, Jeypore, Lakhimpur Division, Upper Assam.

Hollong-Nahor Natural Regeneration, Jeypore, Lakhimpur Division, Upper Assam.

Elephants loading logs in typical Hollong-Nahor Forests, Lakhimpur Division, Upper Assam.

Typical Hollock plantation in Upper Assam, 6–8 years old.

Hollong Natural Regeneration, Digboi, Upper Assam.

Sasi (*Aquillaria agallocha*) plantations, Sibsagar Division, Assam.

Working Plans

The first Working Plan Division was created in 1889, but it was abolished in 1895 and not revived again until 1926, though various officers wrote plans in-between.

The earliest plans were naturally for the Sal forests of Lower Assam, the Garo Hills and Goalpara plans being compiled by 1893. Among the more notable plans was Perree's plan of 1906 for the Goalpara forests, when he carried out a total enumeration of Sal in the Reserves down to 3 feet girth and laid out the parallel ride lines which have been so useful in working the forests.

Early schemes were severely hampered by lack of demand. Under the original unregulated fellings trees were sold at very low rates, but royalties were gradually raised. In attempts to break away from the system of extraction by *daffadars* or log-cutters who creamed the forests of the best trees, departmental operations were attempted but were not financially successful. As the demand for timber increased there was a gradual evolution from the Selection system though Improvement Fellings to the Uniform System under which most of the best Sal forests of the plains areas are now worked.

Silviculturally the greatest step forward was the abandonment, in 1915, of fire-protection, which it was realized was bringing about increasingly evergreen conditions in Sal forests, and since then the judicious use of fire to regenerate the forests naturally has been a feature.

In Central and Upper Assam, after the early unregulated fellings Selection fellings to girth-limits with a felling cycle for the working out of miscellaneous species was tried, as well as the system of purchase-contract under which blocks were marked and leased out to contractors for a few years at a time. Owing to the demand being mainly for the more valuable species the forests were worked out in an unbalanced manner, and there is at present a general shortage of such trees, which with the poor demand for other species, makes working under any recognized system difficult. It is here that the modern conception of "Compensatory plantations", which permits the removal of yield from the main forests by Selection fellings while it is replaced on a *prorata* basis in accessible areas in the form of plantations, is so useful.

The present systems followed in the Working Plans for the miscellaneous and evergreen forests of the State may be described as Selection *cum* Improvement with "Compensatory plantations" in the former and natural regeneration in the latter.

With the permanent creation of a Working Plan Division in 1926, steady progress in the preparation and revision of plans was made and almost all forests were brought under Working Plans within the next 15 years. But with the interruption brought about by the war years the situation deteriorated, until in 1948 the position was reached that all plans except that for Sadiya Division had expired. At present no less than seven out of twelve Divisions are being managed under the prescriptions of expired plans, but with the sanction recently of a second Working Plan Division the position is expected to right itself.

The following statement shows the position regarding areas under working plans in the State :—

		acres
(*a*) Total area of the State under Reserved and Protected forests	..	40,93,861
(*b*) Total area of the State under Plans current and expired	..	31,41,323
(*c*) Total area of the State stockmapped	..	16,37,950

		acres
(*d*) Total area of the State enumerated	.. .. ..	13,55,126
(*e*) Total area of the State managed under different systems :—		
(i) Improvement Fellings ..	.. .. ..	62,149
(ii) Selection *cum* Improvement	.. .. ..	56,68,154
(iii) Conversion to Uniform	.. .. ..	89,232
(iv) Clear-felling and Planting	.. .. ..	2,28,723
(v) Artificial regeneration with or without shelterwood	..	3,187

Utilization

In an undeveloped State like Assam utilization has, inevitably, never been at a high level. This has been due mainly to two factors – the low level of internal consumption of forest products and of timber particularly, and the poor extraction facilities hitherto available. Assam's buildings are largely made of bamboos, reeds, grass, and cane and with the generally plentiful and free supplies of these materials from the Unclassed State Forests the rural dweller has never required anything more than a few posts for his house-construction. On the other hand the difficulties of extraction have resulted in a large percentage of the out-turn of the tree being left in the forests. Inspite of attempts in the past to introduce mechanical methods of extraction, the elephant and the buffalo for dragging logs and the bullock cart for carriage continue to be generally indispensable, though it is correct to say that since the 2nd World War the motor-truck has been increasingly used and in some areas has revolutionized extraction methods by enabling the extraction of logs to depots or saw-mills, as against hand sawing in the forests which was the universal custom previously.

From the export point of view the position has worsened considerably since the partition of India, with the loss of East Bengal markets, and the greatly increased mileage and freight costs to Calcutta markets over the only All-Indian rail route available. Forest industrialization except for a well-established veneer industry, a struggling saw-milling industry, and an infant treatment industry, has practically made no headway in Assam. Therefore, it is probably correct to say that unless local consumption of forest produce, and of fashioned timber particularly, is greatly stepped up and such industries as paper and pulp, timber-treatment, etc., are established, there are small prospects of any great increase in the utilization of Assam's excess forest products.

Fuel and Fodder

With the disappearance of the village forests and the shrinking of the Unclassified State Forests in most districts, fuel and house-posts are becoming scarce, though most households can still boast of a small patch of jungle. Fuel forests have been proposed in some of the Community Projects and Extension Blocks in the more populated areas and there has been a general demand for planting material. The fodder resources of the Reserve Forests are not utilized by any but those immediately in their vicinity and that only for grazing, as stall-feeding of cattle is not practised to any great extent outside the towns. Professional graziers keep herds of buffaloes and cattle on the edges of or inside Reserves.

Soil Conservation

Generally speaking the Reserve forests in Assam play a not inconsiderable part in the protection of soil as they are mainly situated towards and along the outer foot-hills, but the interior hills which contain the catchment areas of most of the larger streams and rivers have

insignificant percentages of Reserves and are given over almost entirely to *jhuming* or shifting cultivation. This is a tragic position, a combined result of the agricultural needs of the hill-people and of shortsightedness in the past. The one saving grace is that the soil does not remain exposed for long because of the early rains and luxuriant growth of vegetation, but as the former generally coincides with the critical period when the new *jhums* have just been burnt and sown, the loss of soil is still very high.

Wildlife

Assam is justly noted for its abundant and varied wildlife, and has a number of unique species, the most notable being the rare Great Indian Rhinoceros. The best conditions for successful *shikar* and photography are to be found towards the end of the cold weather when fires have burnt off undergrowth and the vigour of the jungle has somewhat diminished. The Kaziranga Sanctuary is the most famous of several sanctuaries and contains large numbers of Rhinoceros and Wild Buffaloes, which have to be viewed from elephant-back owing to the swampy conditions and high grass. All in all Assam's forests form a fitting frame for her wildlife both being, to those who know them, abundant and varied.

FORESTRY IN WEST BENGAL

BY N. PAL, I.F.S.
Conservator General of Forests

Summary.—Forest conservancy in the state of West Bengal dates back to 1864. In the present organizational set up there are, in addition to the head of the Directorate, 2 Conservators' Circles, 14 Territorial and 5 Non-territorial Divisions.

Eight distinct formations of forest occur. The principal timber species is *Shorea robusta*. The area of the state is 30,775 sq. miles, while the area under forest is 4,413 sq. miles, the proportion of forest thus being 14%. All areas under forest are worked either under Working Plans or Working Schemes.

Historical perspective and the Organization of the Forest Department

Darjeeling was the starting point of forest conservancy in the presidency of Bengal which comprised of the present States of West Bengal, Bihar, Orissa, Assam, the North-Eastern Frontier Agency and of East Pakistan. After Darjeeling, with its surrounding hills, was ceded to the East India Company by the Raja of Sikkim in 1835 it was decided to make it the summer headquarters of the Government. As the development of the station proceeded the adjoining forests gradually became depleted of timber and firewood. By 1864 it was decided to set apart some lands for the cultivation of tea and cinchona and reserve certain others for the conservation of forests.

The Department of Forests was inaugurated in August, 1864, with the appointment of T. Anderson, M.D. as a temporary Conservator of Forests, and of Mann as an Assistant Conservator of Forests, though both of them had no technical training in forestry. The former was, in addition, the Superintendent of the Botanical Gardens in Calcutta while the latter was the Officer-in-Charge of cinchona cultivation in Darjeeling. The first Forest Division formed with the areas surrounding the station of Darjeeling was called the Sikkim Division, and in addition to the Divisional Forest Officer the staff consisted of 3 (European) Overseers. During 1864–65 the first forest nursery was formed near Darjeeling employing British troops and local labour while in 1868 the very first plantations were formed – one near Darjeeling and another at Bamonpokhri in the *Terai*, the latter being of teak. The first notification in the Bengal Gazette constituting certain lands as Reserved Forest and framing certain forest rules was published in January 1866. The Department gradually expanded and its activities extended. The first unit to secede from the Conservator's charge was Assam (including N.E.F.A.) on its being constituted a Chief Commissioner's province during 1873–74, and then Bihar and Orissa in April 1912, and finally East Pakistan in August 1947.

The present organizational set-up of the Forest Directorate is as below :—

Head of the Forest Directorate – Conservator General of Forests	1
Forest Circles	2

FOREST DIVISIONS

Territorial	14
Non-territorial under the direct control of the Conservator General of Forests	

Silvicultural Division	5
Working Plans Division	
Utilization Division	
West Bengal Forest School Division ..	
Siliguri Saw-Mill Division	

Summary of forest types and forest resources

Following Champion's classification and nomenclature two distinct formations of vegetation and one formation of Alpine scrub occur in this State. Briefly these are: (i) *Wet Evergreen forest*—restricted to the foot-hills of North Bengal. *Michelia champaca, Terminalia myriocarpa, Ailanthus grandis* and *Phoebe* spp., all yielding marketable timber, are characteristic trees of the formation.

(ii) *Moist Deciduous Forest*—This formation is most important for it includes the Moist Sal type and the Wet Hill Sal type, both having a number of sub-types, as also several Primary Seral types such as the Beach Forest and the Tidal Forest of the estuarian Sunderbans, the Tropical Valley Fresh Water Swamp forest of the district of Malda and the *Khair–Sissu* forest of the *Duars* and *Terai*. The most important commercial produce of this formation is yielded by sal (*Shorea robusta*) the others being *Khair* (*Acacia catechu*), *Sissu* (*Dalbergia sissoo*) and *Goran* (*Ceriops* spp.).

(iii) *Dry Deciduous Forest*—This formation occurs on laterite soil in the south-western part of the State in the shape of Dry Sal forest. Sal which is of low quality and height is the most important tree of this type.

(iv) *Northern Sub-tropical Wet Hill Forest*—A type of this formation holding *Betula cylindrostachys, Alnus nepalensis*, etc., occurs in the North Bengal hills up to 6,000 feet altitude.

(v) *Northern Wet Temperate Forest*—This formation is represented by one type only occurring between 6,000 and 9,000 feet altitudes on the hills. The most important commercial species are *Juglans regia, Michelia excelsa* and *Betula alnoides*.

(vi) *Himalayan Moist Temperate Forest*—Two types of this formation occur between 7,500 and 11,000 feet altitudes on the hills; the commercially important trees found here include *Tsuga brunoniana, Abies densa, Magnolia campbellii* and *Betula utilis*.

(vii) *Himalayan Dry Temperate Forest*—This formation is not important being represented by a Primary and a Secondary Seral Type, the former being the Alder Woods and the latter the Temperate Bamboo Brakes.

(viii) *The Alpine Forest having an altitudinal range between 9,500 and 11,500 feet*—The most important tree of this formation is *Betula utilis*.

Statement of Areas

Area of the State	Forest area					Proportion of existing forests to State area and proportion aimed at
	Reserved	Protected	Private	Unclassed State Forest	Total	
sq. m. 30,775	sq. m. 2,671·6	sq. m. 1·27	sq. m. 1,421·37	sq. m. 318·99	sq. m. 4,413·23	14·34/25%

Status of regeneration, natural and artificial. Nature and extent of plantations

In the tidal forest of the Sunderbans regeneration is wholly natural. Blanks, large and small occur mostly in the parts farthest from the sea where the level of earth is higher and the tide water cannot deposit sufficient silt to provide anchorage to the water-borne seeds. In the extensive laterite area in the south no natural regeneration is possible due to soil erosion and grazing, and regeneration has to be wholly artificial including coppice. Given a reasonable chance *Barringtonia acutangula*, the principal species of the Tropical Valley Fresh Water Swamp Forest reproduces itself naturally. In the wet parts of North Bengal natural seedlings of Sal are either damped off or are choked to death by rank vegetation and evergreen species, and it is only in the small *Bhabar* tracts that aided natural regeneration has been successful. Artificial regeneration of Sal by the *Taungya* method has proved most successful and is practised on a fairly large scale. On the hills of North Bengal artificial regeneration with and without *Taungya* is practised, but in the former case the raising of field crops is restricted to one season only as a safeguard against soil erosion. The most important timber species raised artificially are *Shorea robusta, Tectona grandis, Chukrassia tabularis, Dalbergia sissoo, Juglans regia, Betula* spp. and *Michelia* spp.

Areas under plantation are as below :—

North	Hill ..	43·9	sq. miles	up to 1953
	Plains ..	58·7	,, ,,	
		102·6	,, ,,	
South	Laterite area ..	14·7	,, ,,	up to 1954
	Alluvial and coastal area ..	11·8	,, ,,	
		26·5	,, ,,	

Silvicultural Problems and Silvicultural Research

Shorea robusta presents the most formidable problem both in the Moist Deciduous Forest in the north and in the Dry Deciduous Forest in the south, but the problems are not identical. In the north regeneration has to be artificial for reasons stated earlier, but due to the inadequacy of *taungya* labour and the difficulties of disposing of existing timber owing to the railway bottleneck regeneration up to the working plan prescriptions has not everywhere been possible. Nature has been thrown out of gear as it were in the laterite area in the south due to the prolonged mismanagement of the soil by man. There the regular monsoon does not break till the very end of June or even early July, but the seeding of Sal is over by the 1st week of June. There is thus a dry gap of at least 3 weeks. Research has been undertaken to work out ways and means to get over the impasse by seed storage and by raising seedlings in the nursery in paper tubes and transplanting them on the arrival of the monsoon. The latter system has been fairly successful although somewhat expensive.

A very tenacious grass growing to about 2 feet tall, and known as *Desmostachyum bipinnata* constitutes a major problem in certain parts of the Southern Circle. It multiplies very fast and inhibits the growth of seedlings mainly by root competition. The only solution is to dig it out wherever it occurs too close to seedlings.

Experimental cultivation of certain plants yielding economic products, such as *Acacia decurrens, Acacia mollissima, Morus alba, Santalum album, Cinnamomum camphora*, etc., is under way.

The Silvicultural Research Section maintains 198 Sample Plots, 13 Diameter Increment Plots, 17 Experimental Plots, 22 Preservation Plots, 16 Linear Sample Plots, 3 Arboreta and 4 Research Stations.

Position in regard to Working Plans, their preparation and revision

All the 6 Divisions in the Northern Circle and the 24-Parganas Division in the Southern Circle which are composed of reserved and protected forests are under sanctioned Working Plans. There is a Working Plans Division which is entrusted with the revision of the Working Plans and with the checking of control forms of the 7 Divisions mentioned above. The remaining 7 Divisions in the Southern Circle are made up of private and unclassed State forests. The unclassed State forests under the management of the Forest Directorate are worked under Working Schemes, and so are the vested private forests. The controlled private forests are worked under very simple Working Plans either drawn up by the Regional Forest Officer himself, or drawn up by the proprietor and sanctioned by the Regional Forest Officer with or without modifications.

Extension forestry ; avenue, canal and railway plantations, farm forestry, fuel and fodder reserves, etc.

The banks of main canals of the Mayurakshi system in the district of Birbhum have been planted up mainly with teak, *Sissoo*, *Acacia arabica* and *Sabai* grass (*Eulaliopsis binata*) over a length of 30 miles, as also a mile length of sea dyke on the Contai coast in Midnapore district. A total area of 7,561 acres of waste lands has been planted up in the alluvial and coastal zones of this State since 1948.

Production data and marketing arrangements, Utilization problems

The Forest Directorate runs a sawmill at Siliguri in North Bengal which turns out annually some 3,000 tons of converted timber. A seasoning kiln is attached to the Sawmill. The outturn of the mill is supplied against orders at agreed rates or by auction in lots. In North Bengal where the forests hold big timber, standing trees and round timber are generally sold in lots by auction or tender. Minor produce except certain special items like ivory, rhino horn, honey, etc., is usually sold by permits where the quantity is specified either in terms of weight or number of loads. Green firewood and split firewood are sold at scheduled rates principally to the Tea industry. A large quantity of honey (about 5,000 maunds) produced by the Rock Bee (*Apis dorsata*) in the tidal forests of the Sunderbans during April, May and June is collected by private agency ; out of this a small quantity is bought up by Government, machine-filtered and bottled and sold for the benefit of the small consumers.

The largest consumers of timber are the railways. A keen demand for timber exists in South Bengal, but very little can be sent from the North Bengal forests due to the railway bottleneck.

The production data for the reserved forests are given below for the year ended March 31st, 1951.

	TIMBER		FUEL
Round c. ft.	Wrought c. ft.	Total c. ft.	c. ft.
4,988,000	131,000	5,119,000	14,122,000

MINOR FOREST PRODUCE

					Quantity	Value Rs.
1.	Bamboos	..	..	Nos.	1,252,450	24,733
2.	Fodder	..	..	..	..	23,748
3.	Cane	..	..	Mds.	31,300	15,650
4.	Stone and sand	..	..	C. ft.	4,050,977	82,569
5.	Thatch grass	..	..	..	..	19,748
6.	*Khair*	..	..	Mds.	466	191,686
7.	Honey	..	..	Mds.	3,705	55,318
8.	Bees wax	..	..	Mds.	586	13,409
9.	*Golpatta* (leaves of *Nipa fruticans*)	..	..	Mds.	60,000	6,619
10.	Miscellaneous	..	..	..	..	60,224
					TOTAL :	496,704

Forestry as an agent in soil conservation

There is ample evidence of the disastrous result of denudation both on the hills where the rainfall is over 150 inches, and in the dry laterite zone in the south-west where the rainfall varies between 40 inches and 55 inches. In the former area badly eroded hillsides showing bedrocks are not an uncommon sight, especially on steep slopes, while in the latter, where pressure of population is high at least a thousand square miles have been rendered incapable of bearing the less exacting forest trees, leave alone food crops. Afforestation of the highly eroded areas in the laterite zone has been successfully done since 1948 with the closure of grazing, and surface erosion has been fully checked in the areas afforested. The total area afforested up-to-date in this zone is 9,432 acres.

Wildlife

There are five game sanctuaries in the State as noted below, the last one being an island situated in the tidal forest of the Sunderbans, and the one before that being on the Darjeeling hills. The remaining three, which are in the *Duars* are specially maintained for the preservation of the fast disappearing species of the Indian Rhino known as *Rhinoceros unicornis* of which 60 to 70 animals are still left.

	Name and area (in sq. miles) of Sanctuary			District in which situated and year of formation	
1.	Jaldapara	..	36·00	Jalpaiguri	1941
2.	Gorumara	..	3·33	Jalpaiguri	1949
3.	Chapramari	..	3·40	Jalpaiguri	1939
4.	Senchal	..	15·27	Darjeeling	1940
5.	Lothian Island	..	14·67	24-Parganas	1948

Various views of artificial regeneration operations in the forests of West Bengal—showing young plantations.

Of the animals occurring in the State the following are worthy of mention :—

English or Vernacular Name	Latin Name	REMARKS
Indian elephant	*Elephas maximus indicus*	Number declining owing to pressure of human population.
,, rhino	*Rhinoceros unicornis*	60 to 70 animals survive.
Wild buffalo	*Bubalus bubalis*	Number declining and about a dozen animals are left.
Indian bison	*Bibos gaurus*	Number declining mainly due to rinderpest.
Swamp deer	*Rucervus duvaucelli*	Rare and restricted to the Jaldapara Sanctuary.
Sambhur deer	*Rusa unicolor*	Number declining due to increased density of forest.
Chital deer	*Axis axis*	Number declining. Restricted to the thinner forests and the Sunderbans.
Hog deer	*Hyelaphus porcinus*	Number declining with the reduction of savannah.
Barking deer	*Muntiacus muntjac*	Has the widest range of distribution from the tidal forest to 8,000 feet on the hills.
Thar	*Capra jemlaicus*	Cliff dweller. Goat-antelope.
Ghoral	*Nemorhoedus goral*	Do.
Royal Bengal Tiger	*Panthera tigris*	All are man eaters in the tidal forest of the Sunderbans.
Himalayan black bear	*Ursus torquatus*	More carnivorous than the Sloth Bear.
Sloth bear	*Melursus ursinus*	Confined to the hot plains.
Indian wolf	*Canis pallipes*	Confined to the hot laterite area in the south.
Striped Hyaena	*Hyaena striata*	About a dozen animals occur along the sea sand.
Red dog	*Cuon dukhunensis*	C onfined to North Bengal.

THE FORESTS OF BHOPAL STATE

BY K. R. N. PILLAI, P.F.S.
Conservator of Forests, Bhopal

Summary.—A brief history is given of the State forests of Bhopal, describing their situation, configuration of the ground, drainage, climate and rainfall. The history of the forests from 1868 to-date given here deals with the main types, principal tree species, state of natural reproduction, plantations and nurseries, methods of extracting the major and minor produce, the principal markets, soil conservation measures, wildlife and its protection, etc.

The forests are at present worked on a system of Coppice-with-Reserves on a 40-year rotation. The main species, viz., teak (M.P. Quality IV) meets the local requirements leaving a small surplus for export The chief items of Minor Forest Produce are bamboo, grass, *tendu* leaves, *katha* and *kulloo* gum.

General description of the tract

Topography—The Bhopal State stands on the eastern confines of the Malwa plateau and consists of undulating country, composed of rich, black cotton soil interspersed with low sandstone hills, which merge into a succession of tangled ridges towards the east and south, forming an arm of the great Vindhyan Range. The highest peak is about 2,385 feet above mean sea-level and the average elevation is in the neighbourhood of 1,600 feet.

The tract thus divides itself off into two parts :

(i) The plateau proper, supporting a highly fertile country, having a total area of about 4,000 sq. miles.

(ii) The hilly region to the east and south, with an area of nearly 3,000 sq. miles. The slopes and foothills are in most parts covered with forest growth, though much deteriorated by heavy fellings, lopping, grazing and fire.

Drainage—The State lies in the drainage basin of two great rivers, the Jamna and the Narbada. The watershed between the two drainage systems is formed by the Vindhyan Range which runs more or less east-west.

Whilst the northern portion of the State is drained by the rivers Betwa and Parbati and their tributaries, which flow towards the Jamna, the Narbada, enriched by a series of streams, traverses about 125 miles to form the southern boundary of the State with Madhya Pradesh.

Situation, Boundaries and Area—The State is bounded by Madhya Bharat along its north, west and south-west, while Madhya Pradesh encircles it along its north-eastern, eastern and southern boundary. Geographically, the State extends from 22° 32′ to 24° 4′ North latitudes and from 76° 28′ to 78° 52′ East longitudes with an area of 6,878 ·5 sq. miles.

Climate—The climate is temperate on the whole, though extremely hot from April to June when the mercury shoots up to 110°–112°F. and hot, westerly winds are experienced. The average rainfall is about 45 inches, almost the entire precipitation being received from June to September.

Geology and Rock—The tract dealt with is overlain with basaltic lava flows, filling in the deeply eroded valleys in the Vindhyas to a depth of 200 feet in places. Geologically, vast areas in the State are rich in such rocks of economic importance as the Vindhyan sandstones

for building purposes, quartzic sandstones for manufacture of glass and limestone and *kankar* suitable for the manufacture of emery wheels, sand papers and sand clothes.

Past Systems of Management – General history of the forests

No proper record of the history of the forest management prior to 1868 is available. Bhopal, however, furnishes but one more example, if example were needed, of the various forms of ravages and vicissitudes which almost every forest in India has had to undergo in its early stage of formation and stabilisation, with which we are so familiar from the classic reports of the early pioneers of forestry in this land. The forests were in the hands of "*Mustajirs*" (a sort of Revenue Farmers) and *Jagirdars* who had no regard for their conservation.

In 1868 a land settlement for 20 years was carried out and all forest land was taken under State management, the *Mustajirs* and *Jagirdars* being duly compensated by payment of a lump sum equivalent to the average income derived from lands during the previous quinquennium. Unfortunately, the settlement was short-lived as it had to be cancelled (obviously through the agitation of the "*Mustajirs*") with the result that all the forest areas taken over by the State were duly returned to them in 1871. Broadly speaking, the next 43 years up to 1941 (when the Department was transferred to the charge of the then Heir Apparent to the *Nawab*) witnessed a series of frequent changes in the management of forest areas between the *Durbar* on the one side and the ever-influential "*Mustajirs*" on the other.

The only happy interlude, during the aforesaid long period of 43 years of misuse and abuse of forests, was the appointment of Shri Nar Singh Rao (then a Ranger and latterly promoted to the I.F.S. in the Central Provinces) through whose commendable efforts a separate Forest Department came into being in 1907. Among other things, Shri Nar Singh Rao seemed to have prepared a demarcation scheme to be subsequently replaced by a form of working on the basis of a sort of annual coupes in 1915, under the system of Simple Coppice in completely degraded areas and Coppice with Standards in the better ones. The most mentionable efforts at conservancy appear to be the first attempt at fire protection in 1927–30, the absence of which had contributed to the degradation and depletion of the forests. No rotation was fixed and there was no control over the yield. Coupes were prepared haphazardly and in selected areas only, and their location was often dictated by the local contractors. The first Working Plan prepared by Shri Sirkar during the period 1934 to 1937, prescribed Coppice with Standards (later changed to Coppice with Reserves) and high forest. This plan is overdue for revision which could not be undertaken for want of an experienced officer. The working of the area is, however, being carried out with the necessary modifications mostly under the system Coppice with Reserves.

General Description of the Forests

Owing to the generally uniform character of the rock and soil found throughout the State, there is only one marked type of forest, namely, the mixed-deciduous type, in which teak is by far the most important tree. The composition, stocking and condition, of the forest, however, vary much from place to place ; the Working Plan has, therefore, classified the crop, into three distinct types namely : (i) Teak, (ii) Mixed and (iii) Bamboos. In the drier localities, and particularly where the forests have been subjected to unregulated fellings, excessive grazing and repeated fires, few species other than teak have been able to withstand the adverse conditions, and here teak tends to form pure crops.

The commonest associates of teak in these mixed forests are *Terminalia tomentosa*, *Anogeissus latifolia*, *Pterocarpus marsupium*, *Lagerstroemia parviflora*, *Chloroxylon swietenia*, *Diospyros melanoxylon*, *Ougeinia dalbergioides*, *Lannea grandis*, *Sterculia urens*, *Madhuca*

latifolia, *Boswellia serrata*, *Buchanania latifolia* and various other trees. The prevailing bamboo is *Dendrocalamus strictus*, though a large area is found to have been occupied by *Bambusa arundinacea* in the river valleys and other moist situations. On ridges and drier hill-slopes, the forest is often composed of such species as *Boswellia serrata*, *Sterculia urens*, *Cochlospermum gossypium* and *Euphorbias*.

As a rule these dry mixed forests do not contain trees of any large size and the quality varies from what may be termed pole producing forests, where the principal species attain a maximum height of 40–50 feet and a girth of 3–4 feet corresponding to the Madhya Pradesh IV quality (verging on M.P. III quality in places), down to mere scrub where the maximum height growth does not exceed 20 feet. By far the greater proportion of the forests is, therefore, fit only for the production of small-sized timber and fuel, but they are none the less important because it is just these commodities which are most required by the local population.

The following statement shows the areas under different kinds of forest as on 1–4–1954, i.e., after the abolition of *Jagir* areas in 1953 :—

Area of the State	Reserved forests	Protected forests	Civil or Revenue forests	Private forests	Total area under forests	Proportion of area under forests to total land area of the State
1	2	3	4	5	6	7
6,878·5 sq. miles (44,02,240 acres)	1,246·6 sq. miles (7,97,824 acres)	716·44 sq. miles (4,58,521·6 acres)	367·0 sq. miles (2,34,880 acres)	9·6 sq. miles (6,144 acres)	2,339·64 sq. miles (14,97,369·6 acres)	34%

The Status of Regeneration Natural and Artificial – Nature and Extent of Plantations

Natural reproduction is generally unsatisfactory except in the moist inaccessible localities where fire and cattle do not do much damage.

Artificial regeneration of teak is still in its initial stages and is mainly confined to filling in of blanks in annually felled coupes. A start has, however, recently been made in creating nurseries and raising plantations in all the ranges of the State, as a result of which there are at present about 200 acres under plantations. This work has not assumed tempo owing to shortage of experienced staff. It should, however, be noted that there is ample scope for extension of this work.

Silvicultural Problems and Silvicultural Research

The Silvicultural problems are not so complex as to require the establishment of a separate Silviculture Research Branch. Advantage is taken of the results of research conducted by the Forest Research Institute, Dehra Dun, and problems are referred to the Research Institute as and when they arise.

Note :—There were no "Protected Forests" before, but the area shown under col. 3 above is *Jagir* forest just resumed by the Govt. and has been declared as "Protected Forest" pending settlement and notification as "Reserved Forest".

Position in regard to Working Plans, their preparation and revision

As alluded to in a foregoing paragraph, the revision of the Working Plan is kept in abeyance for the last three years for want of a suitable and experienced officer and complement of field staff for stock-mapping, etc. Persistent endeavours made to recruiting the requisite staff having proved futile and the note of urgency having become imperative owing to the resumption of about five lac acres of *Jagir* forests in a battered and semi-ruined condition, the Government of India have been appraised of the position with a request to assist the State in the matter of securing the additional personnel for want of which no forward step can be taken. The revision of the Working Plan is actually tantamount to a preparation of the Plan *de-novo*.

Extension Forestry, Avenues, Canal and Railway Plantations, Farm Forestry, Fuel and Fodder Reserves, etc.

With the abolition of the *Jagirdari* system in Bhopal 4,58,521·6 acres of *Jagir* forest have come under the control of the Forest Department, and which have been declared as "Protected Forests". Endeavours are being made to rehabilitate these forests as quickly as possible. Action for taking over potential Revenue areas (*Mal* areas) is also underway and it is proposed to create Village Forests at suitable places. As the irrigation schemes under the Community Projects and Extension Schemes are on the march it will afford extensive scope for covering the bunds with suitable species with particular emphasis on fuel variety.

Production data and marketing arrangements – Utilization problems

Exploitation of forest produce, both major and minor, is all now being done through private agency such as contractors, lessees and permit holders. The area is sold by public auction, and exploitation is done by contractors. The area of the timber coupes sold out at the recent auction was about 14,867 acres, and the price fetched was over 21 lac rupees. Most of the small-sized timber, firewood and to a very little extent charcoal are consumed within the State ; large-sized timber is mostly exported. Ujjain, Ferozabad, Bombay and Delhi are the markets. A good few contractors have set up small saw-mills in Bhopal and there is also a proposal for setting up a small seasoning plant.

The estimated annual outturn of major and minor produce is detailed below :—

Produce	Estimated outturn	Value realized during 1953–54
		Rs.
Timber	52,100 c. ft.	10,30,036
Firewood and charcoal	1,27,000 c. ft.	95,994
Bamboos	7,50,000 Nos.	42,554
Grass and grazing	2,50,000 Mds.	1,40,456
Gum	8,00,000 lb.	1,62,000
Katha	1,000 Mds.	25,835

Soil Conservation

The effect of erosion is more acute in the Narbada River valley than elsewhere. A soil Conservation and Land Utilization Board comprising of 8 members including the Conservator of Forests as its Secretary was formed in March 1954 with the following objects :—

(i) To assess the extent of soil erosion in the State and to carry out a survey.

(ii) To prepare plans for the control of erosion, and for soil conservation.

(iii) To draw up rules for improved land use for legislation.

(iv) To draw up a scheme for execution of the plans for soil conservation.

(v) To arrange for demonstration, research and training.

Wildlife

Generally speaking, Bhopal offers good shooting to sportsmen, as it holds within its boundaries almost all kinds of game, both big and small, such as are found in the highlands of Central India. The fauna resembles closely that of Madhya Pradesh, both in variety and size. It will be interesting to note in this connection that the biggest recorded *sambhar* head in India came from Bhopal. Bison, wild buffalo and *barasingha* do not occur in Bhopal.

Facilities for shooting, specially for a sportsman from outside, are, however, not adequate. The bottleneck is the absence of a good road system in the forest regions. Rest-houses are few and far between, Reserved Forests are widely scattered and they are honey-combed with Revenue and *Jagir* areas. The approach to many of the shooting blocks, even in fair weather, is not very easy and sturdy jeeps are as essential a requisite as *shikar* kit for any sportsman wishing to do shooting in Bhopal.

The preservation and shooting of wildlife in Bhopal are regulated as under :—

(1) The Bhopal Wild Birds and Animals Act (No. III of 1930) and various notifications issued thereunder.

(2) The Revised Shooting Rules of 1951.

The former is better than the Wild Birds and Animals Protection Act, 1912 of the Government of India on which it is based. The Revised Shooting Rules are on the lines of the Madhya Pradesh shooting rules, which are fairly satisfactory. The Bombay Game Act is undoubtedly an improvement on the existing rules which are generally in force in many States of India. The enforcement of the aforesaid Act and the Shooting Rules are fairly adequate to afford protection to wildlife, but instances of abuse are not uncommon. Destruction is mainly directed towards antelope, *sambhar* and other kinds of deer in order to secure venison with the result that many areas formerly teeming with black buck and other deer species are now found depleted of them.

BIHAR'S FOREST DEVELOPMENT

BY S. S. PRASAD, I.F.S.
Chief Conservator of Forests, Bihar

Bihar's crowning post-war and we might say, post-independence achievement has been the taking over under its management of the privately-owned forests of the State. Of a supposed total forest area in the State of 14,000 square miles (this figure is based on the computation made in 1945 from the Revisional Survey and Settlement figures), as much as 12,500 square miles were at the end of World War II, under private ownership. The position has of course undergone a very great change following the vesting of the estates in the State under its Land Reforms Act.

If the reader will examine a map of the State showing the incidence of forests, he will be struck by its very unevenness in the different parts of the districts. Bihar can be divided into three main regions, namely—

(i) North Bihar – i.e., the territory to the north of the river Ganga : mostly the Gangetic plains area ;

(ii) The central areas, which constitute the South Bihar districts ; and

(iii) The southern high-lands containing numerous hills and several rivers which flow direct from the State into the Bay of Bengal.

On the extreme west of North Bihar is a small section of the Sameshwar Hill in the foothills of the Himalayas, but these forest-clad mountains with their wealth of vegetation are for the most part beyond the Nepal boundary and the bulk of North Bihar is occupied by the large alluvial plain of the Ganga, densely populated and closely cultivated. This plain varies from 70 to 90 miles in width, north to south. The area of North Bihar is 14,677 square miles and, of the forests therein, 364 square miles, or a bare 2·4 per cent.

In South Bihar, the forest areas rise up to 1,956 square miles or only 7 per cent of the total land area.

The Southern area is a region of plateaux and mountainous spurs which are the eastward termination of the huge Satpura–Vindhyan massif which radiates from Amarkantak in Madhya Pradesh with an elevation 3,493 feet above sea-level. Formerly a densely forest-clad country, which is now more or less denuded of forest except on the broken flanks of the plateaux and the more rugged hilly outliers it was, until Government took over control, becoming worse every year. This denudation is no doubt correlated with the disastrous floods that take place periodically, both in the Gaya district to the north, in parts of the Santal Parganas and, along the course of the Damodar in Bengal. This southern tract is known as Chotanagpur. The total territorial area of the tract is 27,708 square miles, of which forests extend over 9,053·82 square miles, i.e., 32·61 per cent of the area.

The necessity of preserving the forests in the southern tract had attracted the attention of the Governments of the time ever since the creation of the State in 1911. The then parent province of Bengal was vitally concerned because of the havoc created by the Damodar river, in the Bengal districts. Nothing much, however, could be achieved until 1930, when the policy of trying and persuading the private forest owners to hand over their forests under section 38 of the Indian Forest Act to Government for management, started bearing fruit. Some of the big landlords, e.g., the Maharaja of Chotanagpur and his tenure-holders, and other land owners could be induced to make over only some of their forests to the Government

for management. The position in so far as it relates to the agencies for management of the forests in the State at periodical intervals is reflected in the following table :—

Year	Total area of forests in the State	Total area of forests owned by Government	Government owned forests under the management of the Forest Department	Total area of forests owned by private agency	Total area of private forest under the management of the Forest Department
1	2	3	4	5	6
			(square miles)		
1924	15,653	1,953	1,790	13,700	Nil
1934	15,560	6,949	1,697	13,611	46
1944	15,622	2,010	1,700	13,611	341
1954	11,761	2,010	1,700	9,751	9,751

The figures for private forests for the years 1924, 1934 and 1944 are only computations and rough estimates, since no accurate data are available. The figures for 1954 are based on actual demarcations, hence the large variation. It would not be correct to say that some 4,000 square miles of forest disappeared between 1944 and 1954, but, none the-less World War II was responsible for extensive and excessive exploitation of a fairly large area of private forests.

It will be seen that by 1954 practically all the privately-owned forests had passed on to Government for mangement. This is by virtue of the enactment of the Bihar Private Forests Act.

When the first Congress Ministry was formed in 1937 and had come to be associated with the administration of the State the present Revenue Minister, Shri K. B. Sahay, then a Parliamentary Secretary, conceived the idea of a Chotanagpur Private Forests Act. Shri Sahay felt that the conservation of the forests of Chotanagpur was vital to the well-being of the people of Chotanagpur and of the South Bihar districts which, earlier in this article, have been termed as the Central Tract. By this proposed enactment he wanted to take over under Government control all the privately-owned forests of Chotanagpur, not too far damaged for proper forest management. Unfortunately, the Congress Ministry resigned in September 1939, that is, at the beginning of World War II, and the matter suddenly received a set back. The onset of World War II and the need for large quantities of timber that came in its wake, however, brought in Bihar mass-scale exploitation of the privately-owned forests. Bihar during the War years was supplying an average of 50,000 tons of timber for War requirements of which a bare 10,000 tons or so came from the Government-owned forests. War-time requirements had to be met. On the other hand, as soon as the situation eased the problem of rehabilitating the much worn and worked-out private forests attracted the attention of the then Conservator of Forests, the late Mr. Sabharwal, I.F.S., and resulted in the enactment of the Bihar Private Forests Act, 1946 a Governor's Act which came to be placed on the Statute Book in February 1946. The old Chotanagpur Private Forests Act had, at the initiative of the then Governor of Bihar, Sir Thomas Rutherford, been enlarged in its scope so as to cover the then entire province of Bihar. By this Act, Government were empowered to take over for management any private forest which they considered to need proper management and the conservation of which was called for. The Congress Government came back to power in

April 1946. The Bihar Private Forests Act, 1946, was in due course substituted by the Bihar Private Forests Act, 1947, an Act duly passed by the Legislature. As the result of the passing of this Act, all privately-owned forests started coming under Government control and management. As much as 9,500 square miles of forest under private ownership have in consequence been transferred to the Bihar Forest Department.

To put these 9,500 square miles under proper forest conservancy, the need arose for demarcation, for forest settlement, and for a properly organized administration and sound working plans, trained forest staff and a sound forest policy. The demarcation work presented very great difficulties. A large staff of *amins* and surveyors, as also of supervisory demarcation staff had to be recruited to get through the work. Fortunately we have been able to accomplish that big work of demarcating 9,500 square miles of forest, and it took us 5 years to do it. As can be imagined, considering the stage at which forest conservancy came to be applied to these private forests, the number of linear miles of boundary lines to a square mile of forest has been on an average as much as 10 linear miles. Most of these privately-owned forests were honey-combed with cultivation. A very great difficulty set in when the owners and the tenants both started an insensate race of destruction following the enactment of the Bihar Private Forests Act. The landlord in his ignorance thought that his forests were to go away from him on the application of this Act, for all time. The tenant also thought that he was going to lose all his forest rights. The Act, as has been framed, merely contemplates the taking over by the Government for management the landlord's forests and the paying to him the net profits after meeting the cost of their management. An allowance of forest income at the rate of Rs. 40/- per square mile, was also to be paid to the landlord, as an interim measure, i.e., until the forests started paying their way. The peoples' rights as recorded were also fully honoured and as many as 19 Forest Settlement Officers started functioning all over the State at the same time to determine and record the nature and the extent of the rights admitted to the private individual over the forests.

One very great difficulty was the non-availability of the trained staff required to manage these privately-owned forests. The number of Forest Guards had to be increased from 356 to 2,300 ; that of Deputy Rangers and Foresters from 63 to 388 ; and of Forest Rangers from 18 to 94. The Gazetted cadre had to be increased from 15 to 39. While Forest Guards and Foresters used to be recruited without training, and had to be so recruited in the emergency created, not so, the Forest Rangers and the Gazetted Forest Officers. But to eventually train up the Forest Guards, and the Foresters, the State has established 4 Forest Guards' Training Schools which impart training by six-monthly courses and turn out 200 trained Forest Guards annually. There is also a Foresters' training School of this State which annually trains up 20 Foresters. Bihar has been fortunate enough to secure 10 seats annually during last 5 years at the adjoining Foresters' School at Champua in Orissa ; thus, 30 Foresters are being trained annually at the Foresters' Training Schools. In 1949–50, the State was allotted 15 seats at the Shivapuri (Gwalior) Foresters' Training School.

A sustained programme of recruiting and training up Forest Rangers has been drawn up for the State and as many as 69 Forest Rangers have been trained at the Forest Rangers' College, Dehra Dun from 1947 to 1954. The Gazetted cadre at present consists of 39 officers, of whom as many as 31 entered service after April, 1947. In respect of the Gazetted Officers also a programme of recruitment and training has been drawn up.

The number of Forest divisions in the State has risen from 9 in 1945 to 28 in 1954. Two Working Plans divisions are now functioning – one having been newly-created to meet the new situation. Working Plans for four out of the 13 newly-created forest divisions have been compiled and are ready. They are under preparation for six more divisions. 16-inch cadastral maps showing the forests taken over and their boundaries are ready for all the

forests. 4-inch reductions are being prepared from these, for purposes of Working Plan work. In Ranchi district, the Survey of India have prepared enlargements of the 1 inch = 1 mile topo-sheets on the scale of 1 : 25,000 and have shown the forest block boundaries on them. It is expected that by June, 1956 Working Plans for all the private forests taken over by the Government, will have been compiled and sanctioned. A separate Forest Research division has also started functioning from 1949 ; it used to be combined prior to 1949 with the single Working Plans Division. It is taking up the works of forest research and forest utilization. An Afforestation Division has been created from August, 1951 to afforest the blanks and barren areas of the State and thereby to reinforce the forest position of the State. This Afforestation Division with more to be and reinforced by the efforts of the Damodar Valley Corporation at afforestation in the upper catchment of the Damodar has set a target of afforesting 1,000 square miles of area in the next 20 years.

In the management of these privately-owned forests taken over by the Government, all recorded rights to forest produce have been respected, the value of the produce and of the free grazing given away to the right holders being variously estimated at 50 lacs to a crore of rupees. The non-rightholders get their requirements of forest produce at concession rates, i.e., at rates within the capacity of the people to pay. If timber or bamboo coupes are auctioned off to coupe contractors this is done under the stipulation that local demands must first be satisfied at the stipulated rates, before any export of forest produce from the coupe for commercial purposes is undertaken. A ban has been placed in the State on the export of timber and firewood by railway to territories outside the State. Inspite of all these restrictions on the free trading of timber and firewood, from the private forests, the financial picture of the Forest Department has not been bad. It is reproduced below :—

Year	Revenue	Expenditure	Surplus
	Rs.	Rs.	Rs.
1946–47	26,89,581	16,50,965	10,38,616
1947–48	32,30,457	23,72,523	8,57,934
1948–49	42,95,318	31,04,067	11,91,251
1949–50	54,90,609	39,68,509	15,22,100
1950–51	66,84,560	46,15,509	20,69,151
1951–52	61,77,265	51,46,232	10,31,033
1952–53	67,15,845	52,18,367	14,87,478
1953–54	66,23,134	57,58,707	8,64,427

These items of expenditure include large-scale capital expenditure on the construction of forest rest-houses and quarters for the accommodation of Foresters and Forest Guards, for forest demarcation and for the training of the staff, for the compilation of Working Plans and for afforestation. The Bihar forest department's financial results have thus actually been much brighter than is exhibited by the above financial picture.

THE FORESTS OF BOMBAY STATE

BY N. S. KAIKINI, A.I.F.C.

Conservator of Forests, Poona

Summary—This article deals briefly with the historical background of forest management in Bombay State and the composition of the main forest growth and its extent, productivity and value are covered. The different methods of regeneration employed and the silvicultural problems encountered and the manner in which they are overcome is dealt with, giving their position of the management of forests through Working Plans. The extension of forestry to non-forest areas and its place in soil conservation programme is indicated. The advances in Wildlife Preservation and the unique development of Forest Labourers' Co-operative Societies receive a bird's eye view.

1. The first attempt at the conservation of forests in Bombay State was made as early as 1845, although Lord Dalhousie formulated a forest policy a decade later in 1855. The first Conservator of Forests, appointed in 1847, was Dr. Gibson, Superintendent of Botanical Gardens, Bombay, who worked under the immediate orders of the Military Department. From 1863 onwards, the controlling staff was increased ; the Assistant Conservators of Forests were placed under the Collectors until 1870. In 1890 the Forest Department was reorganized and in 1893 three Conservators' Circles were founded corresponding more or less to Revenue Divisions. A Chief Conservator of Forests was appointed in 1917 and research appointments for research in Silviculture and Forest Utilization were created in 1939.

2. Bombay State lies in the western portion of the Indian Peninsula and the Western Ghats or Sahayadris run along its western boundary leaving a narrow coastal strip. Above the Western Ghats and to the east lies the vast Deccan plateau and in the northern part, the Satpuda hills and the Tapti River run west to east. The vast Deccan plateau is in the main devoid of forest except for patches of dry mixed deciduous forests containing teak (*Tectona grandis*), laurel (*Terminalia tomentosa*), *siris* (*Albizzia* sp.) and a few other hardwoods of commercial importance growing to but a small size and riverain *babul* (*Acacia arabica*) forests along the river banks. The main forest areas lie within the range of the Sahayadris on the Western Ghats with its many ramifications, the Satpuda hills and slopes on the southern end of the Deccan plateau where the rich forests of Kanara district lie. The bulk of the forests of Bombay State is composed of mixed deciduous forests ranging from moist deciduous forests to dry deciduous forests and dry thorn forests, and the most important commercial timber species in these forests is teak (*Tectona grandis*). Tropical evergreen forests cover a relatively small area in localities with high rainfall in patches along the Western Ghats and a fairly large area in the Kanara where the tree-growth is lofty forming three or four storied forests and in which *Hopea parviflora* and *Hopea wightiana*, *Polyalthia fragrans*, *Dipterocarpus* sp., *Holigarna arnottiana*, *Lophopetalum wightianum*, *Nephelium longana*, *Cinnamomum zeylanicum* and *Artocarpus* sp., are some of the common useful trees.

3. Semi-evergreen forests and non-teak bearing deciduous forests are also found. The largest common area is covered by teak bearing deciduous forests, wherein the other *Injaili* hardwood associate species are *Terminalia tomentosa*, *Terminalia belerica* and *Lagerstroemia lanceolata* and *Lagerstroemia parviflora*, *Dalbergia latifolia*, *Pterocarpus marsupium*, *Adina cordifolia*, *Ougeinia dalbergioides* and *Anogeissus latifolia*. There are no coniferous forests in Bombay State and timber production is confined to hardwoods of broad leaved species. The important commercial timbers are teak, rosewood (*Dalbergia latifolia*), laurel

(*Terminalia tomentosa*), benteak (*Lagerstroemia lanceolata*), *Bijasal* (*Pterocarpus marsupium*), *irul* (*Xylia xylocarpa*), *Kindal* (*Terminalia paniculata*) and *Sandan* (*Ougeinia dalbergioides*).

4. The total area of forests in Bombay State is 20,295 square miles in a total area of 1,10,111 square miles, which gives a proportion of 18·43%, whereas the proportion aimed at is 30%. The details of the areas are given below :—

Total area of the State in sq. miles	Forest Area in square miles					Total
	Reserved	Protected	Communal	Private	Unclassed	
1,10,111	14,079	1,304	5	1,660	3,247	20,295

Out of the total forest area, 16,512 square miles are in charge of the Forest Department and 2,157 square miles in charge of the Revenue Department.

5. The major part of the forests are of the mixed deciduous type in which the most important timber tree is teak. Natural regeneration of teak of seedling origin is, as a rule, inadequate or totally absent. The tree, however, coppices vigorously and the greater part of natural regeneration in the forests of Bombay State is of coppice origin except in the High Forests of Kanara. Teak coppice is found to lose its vigour when the coppice shoots arise from large trees and coppice regeneration is exclusively relied upon only in the Teak Pole areas where the production of small sized timber is the objective. Natural regeneration is for the most part supplemented by artificial regeneration of teak by stump planting on burnt soil. In the valuable teak forests of Thana and in all other places except the High Forests of Thana and the High Forests of Kanara, artificial regeneration is carried out in small patches 1/40th of an acre or more in extent on which the felling debris is heaped and burnt before planting stumps of teak. This system of planting on small burnt patches is called "*Rab*" in analogy to the practice employed in raising nurseries for rice-planting.

6. In the valuable High Forests of Kanara district, where bamboo growth of the two common species *Bambusa arundinacea* and *Dendrocalamus strictus* is dense, large teak plantations of 100 acres or more in extent at one place are raised. The felling debris including cut bamboos is heaped and burnt over the area to be planted up and reburnt till reduced to ashes. Artificial regeneration by planting or sowing is always carried out on burnt areas in Bombay State to keep down the adverse competition of weed growth and give the young plants a stimulus through the fertilizer value of the ash. In recent years, the artificial introduction of some softwooded trees like *Semul* (*Salmalia malabarica*) and other valuable species like *Khair* (*Acacia catechu*), *Gamari* (*Gmelina arborea*), indigenous mahagonies (*Swietenia* sp.) and African *Khaya* species have been carried out, some being still in the experimental stage.

7. The main silvicultural problems arise in securing the regeneration of valuable species in mixed forests and tending the valuable species to the age of maturity in preference to inferior species to yield valuable timber trees. The introduction of valuable exotic species like the *Eucalyptus*, which are fast growning has been investigated with conspicuous success. The non-teak bearing mixed deciduous forests, semi-evergreen forests and evergreen forests present a complex silvicultural problem for regeneration of the valuable species. Experimental planting of species under shade has been carried out in respect of valuable species like *Dysoxylum malabaricum*, *Calophyllum tomentosum*, *Artocarpus hirsuta*, *Holigarna arnottiana*, *Lophopetalum wightianum*, etc., with considerable success.

A view in the Forests of North Kanara district, Bombay State, with a patch of teak-pole crop—in the foreground.

8. Silvicultural research has also been directed towards the propagation of economically valuable plants and *Ocimum kilimandscharicum*, the camphor-yielding *Tulsi* plant has been successfully raised and its cultivation presents considerable economic possibilities. Hill paddy is being raised in-between rows in plantations with considerable gains in revenue and the food grain production. Results of silvicultural research work have provided easy means of raising *Anogeissus acuminata* and *Anogeissus pendula*, two tough woods excellent for tool handles, in dry mixed deciduous forests. *Casuarina equisetifolia* plantations are raised on rotations of 15 and 20 years on available Government land along the long sea coast of the State to yield valuable pole timber and fuel. Recent investigations carried out by brick planting have shown that the planting in bricks saves the expense on watering during the ensuing dry season thus appreciably lowering the expenditure on raising *Casuarina* plantations.

9. A major portion of the forest area in charge of the Forest Department is organized and managed according to the prescriptions of sanctioned Working Plans. 10,608 square miles representing 63% of the forest area is covered by the various Working Plans. With the merger of the former princely States in Bombay, a large forest area has accrued much of which had not been scientifically organized under proper Working Plans. Wherever the status of the forests in the old States has been defined, the forest area is organized under new Working Plans and wherever settlement has yet to be finalized, the forests are worked under provisional Working Schemes. Revision of the Working Plans is proceeding apace.

10. There is vast scope for the extension of forests especially on the dry Deccan plateau, and afforestation coupled with soil conservation work is being carried out employing continuous as well as interrupted staggered trenches. Species of economic importance are mainly introduced and a hedge of agaves serves as an effective fence to keep off cattle, goats and sheep. The afforestation of canal banks has recently been undertaken on Mutha and Ghataprabha canal systems. A scheme for village woodlands and fuel reserves on the Village *Panchayat* Forests system has been drawn up and is expected to be implemented in the near future.

11. The forests of Bombay State are rich sources of hard and heavy hardwoods of which species other than teak do not find much demand. The production of hardwood timber was 2,24,000 tons during 1952–53 and that of fuel 10,25,000 tons. The moist deciduous forests of Kanara are rich in the bamboos *Dendrocalamus strictus* and *Bambusa arundinacea* both of which are found in the forests of Dangs, while the former is met with also in other moist deciduous forests. Minor Forest Produce forms a considerable part of the yield of the forest ; during 1952–53 this fetched a revenue of Rs. 21,68,333/- of which bamboo alone fetched Rs. 7,17,300/-. Forests are sold standing except for the High Forests of Southern Circle where timber is extracted to central Depots under a logging contract, and periodically sold by auction. The main utilization problem is to make other suitable hardwoods available to the consumer in seasoned, ready to use form so as to replace teak wherever possible. There is acute shortage of fuel in the dry barren Deccan plateau areas of the State due to lack of cheap and adequate transport facilities, and cow-dung which should go to the fields as manure is extensively used as fuel.

12. The forest fauna of Bombay State is rich and varied. The protection of wildlife has not been neglected and there is a game sanctuary covering nearly 80 square miles near Dandeli in North Kanara District. The Bombay Wild Animals and Wild Birds Protection Act, 1951, lays down rigid rules for the preservation of wildlife and it has been in operation since 1953. A salient feature of the wildlife preservation activities is the appointment of Honorary Game Wardens from among the public. The Wardens have been very active. The post of Wildlife Preservation Officer has yet to be filled in.

13. An unique socio-economic experiment in the improvement of the living conditions of forest labourers belonging to backward tribes is the formation of Forest Labourers Co-operative Societies to exploit the forests. The number of *Adivasis*, mainly forest dwellers, in Bombay State is roughly 33,59,300 out of a total population of 3,59,56,150 forming about 10%. The living conditions of these people was very low and their pitiable state was first brought to light by Mr. Symington in 1939. With the advent of Independence in 1947, the Chief Minister of Bombay State announced a scheme for the organization of co-operative societies of *Adivasis* to exploit the forests as one plank in the programme of the general and over-all economic betterment of these persons. In the year 1947–48, eleven forest Labourers' Co-operative Societies were started and 19 forest coupes were allotted to them. The coupes are allotted to the Forest Co-operative Societies at upset prices which results in a decrease in revenue. Particulars of the progress made during the last seven years is shown below :—

Year	No. of Societies	No. of members	No. of coupes allotted	Total upset price	Approximate decrease in revenue
1	2	3	4	5	6
				Rs.	Rs.
1947–48	11	508	19	1,80,400	67,411
1948–49	19	705	40	3,82,660	9,831
1949–50	50	835	94	11,72,883	2,55,620
1950–51	78	16,996	143	21,67,515	10,79,698
1951–52	94	20,440	200	18,73,697	11,29,758
1952–53	76	22,521	155	14,75,242	5,40,162
1953–54	77	*	184	16,90,170	5,55,138
1954–55	*	*	237	To be fixed	

* Information not available.

14. The experiment of organizing forest co-operatives for *Adivasis* is unique. It is a venture which is inspired by idealism but fraught with practical difficulties. The *Adivasis* themselves have to run the co-operative societies in the ultimate stage and when that is realized and the benefits go to all the members the experiment would be a success. The experiment has perhaps not ended but appears to be on the road to success.

FORESTRY IN INDEPENDENT BURMA

BY T. CHEIN HOE
Chief Conservator of Forests, Rangoon, Burma

Summary.—The article summariezes information on the activities of the Burma Forest Department since Independence in 1948.

Introduction

Owing to the last war, forestry in Burma suffered a great deal in loss of valuable records, departmental assets and talents built up since its inception in the eighteen fifties. Had it not been for the untiring efforts of the Burmese members of the Forest Service left behind in Burma during Japanese occupation, the loss would have been heavier. The British and a few Burmese members who evacuated to India also kept the other portion of the service alive by drawing up at Simla Rehabilitation Plans for immediate implementation on reoccupation. Though caught under opposing camps during the war, it was just like foresters all over the world to have a common bond in thinking all the time as to how best the forests should be managed for perpetual human benefit. This common bond had contributed a great deal in keeping the high tradition of the service intact and restoring the departmental records into a "workable form" from what must soon after the war be considered a complete chaos.

1. General Policy and Legislation

The nation-wide enthusiasm for the First World Festival of Trees and the afforestation of the Dry Zone under a Welfare Scheme sponsored by the Government are definite proofs of the increasing recognition of the essential role of the forests in their protective functions. There are also signs of general awakening to the need for scientific management of the forest grazing grounds and range lands. The work on the revision of the forest policy continues.

2. Land use planning (including progress in inventory and classification of forest resources)

A start has been made on Land Use Planning with the formation of the Union of Burma Agricultural Planning Advisory Committee to find ways and means for undertaking land classification, physical productivity survey, economic survey, general survey of different sectors including research, credit, standardization and inspection of produce. The Chief Conservator of Forests is on this committee and will serve on the Agricultural Planning Commission that is being formed to set up a permanent Agricultural Planning Organization.

Aerial forest survey over the mangrove forests started in 1923 has been revived and extended to other areas with the co-operation of the Directorate of Aerial Surveys.

3. Administration

Ownership—All forests in Burma are State-owned. Total areas under reserved forests unclassed forests and other lands, as they stand, are given below :—

	sq. miles	hectares	
Reserved Forests ..	34,686	89,83,674	= 13·3%
Unclassed Forests ..	1,15,386	2,98,84,974	= 44·0%
Total Forests ..	1,50,072	3,88,68,648	
Other lands ..	1,11,688	2,89,27,192	= 42·7%
GRAND TOTAL ..	2,61,760	6,77,95,840	

The area for reserved forests includes 923 square miles (2,39,000 hectares) of game sanctuaries.

The policy for future reservation and management of unclassed forests will depend upon the physical and socio-economic requirements of the country.

Organization—The following summarizes the present position of the forest establishment in Burma :—

Senior Administrative post – Chief Conservator of Forests ..	1
Other Administrative posts – Conservators of Forests ..	7
Selection Grade posts – Divisional Forest Officers including research and senior teaching posts	43
Senior Branch posts – Assistants	83
	134

There are five territorial and two non-territorial circles and thirty-four forest divisions.

The Junior Branch is composed of :—

Forest Rangers	134
Deputy Rangers... ..	359
Foresters	1,383

The State Timber Board constituted under the State Timber Board Order, 1948, to control, extract, mill and market forest produce became a statutory body towards the end of 1952.

The average operating coefficient for the Forest Department for the five-year period 1948–49 to 1952–53 is 45·18.

4. Improvement of Forests

(i) *Soil conservation*—With the joint sponsorship of the Forest Department and the Shan State Government, soil conservation work in the Shan State is being expanded. A number of pilot study and demonstration projects are continued.

The highlight in the field of conservation is the implementation of the Welfare Afforestation Scheme in the Dry Zone by the Agricultural and Rural Development Corporation with the help of the Forest Department. It is the first of its kind undertaken in this country. The scheme provides for afforestation, in eight years, of 200,000 acres out of a total of 638,000 acres generally classed as "cultivable waste" in that region These 200,000 acres to be afforested will be in two categories – the township demonstration forests will cover an area of 2,300 acres and the balance of 197,700 acres will form the village welfare forests. Rehabilitation of the Plains Reserves which were severely damaged during the war and the subsequent insurrections is also being taken up as a major operation by the Forest Department.

In the Shan State, Mongmit and certain divisions of the Northern Circle full advantage is being taken wherever possible of the flowering of two bamboos – *Kyathahaung* (*Bambusa polymorpha*) and *Tinwa* (*Cephalostachyum pergracile*) to establish natural regeneration of teak.

(ii) *Protection*—Protection is undertaken as far as conditions permit.

(iii) *Improvement of stands ; Silviculture*—Studies are made of indigenous and exotic species to determine the best nursery and plantation technique and subsequent stand treatment in the Dry Zone. Investigations are also made to solve any pathological or insect problems.

Six indigenous species – namely Cutch (*Acacia catechu*), Burmese *Kokko* (*Albizzia lebbek*), *Mezali* (*Cassia siamea*), *Tanaung* (*Acacia leucophloea*), Burmese *Tama* (*Melia*

azedarach), and *Peikthingat* (*Cassia auriculata*) and six exotic species namely Mesquite (*Prosopis juliflora*), *Subyu* (*Acacia arabica*), *Shisham* (*Dalbergia sissoo*), Green Wattle (*Acacia decurrens*), Black Wattle (*Acacia mollissima*) and Eucalyptus (*Eucalyptus* spp.) were tried.

Management—Revision of Working Plans is well in hand.

Improvement—Work on improvement of growing stock by thinning and improvement felling operations continues to be undertaken but subject to limitations imposed by funds, staff and state of law and order.

5. Utilization

(i) *Logging and transport*—Animal power, chiefly elephants and buffaloes, is still extensively used in the initial stages of extraction of timber from forests to fixed transportation points. With a view to supplementing the present deficit animal power in logging, the State Timber Board has decided to form an Experimental and Training Mechanical extraction Unit as recommended by an FAO Expert. The Unit is expected to start operation soon after the end of 1954.

Motor trucks are being increasingly used for long distance haulage on good roads as this mode of transport has proved to be more economical than carting and at the same time capable of delivering larger quantities of timber with certainty.

There is also a scheme for the development of mechanised timber transportation by extending motorable roads into the forests to increase production and economize on costs.

(ii) *Wood industry*—A master plan based on the FAO report on Integration of Forests and Industries has been drawn up and approved by the Government. A new branch has been formed under the Agricultural and Rural Development Corporation to give early effect to this plan.

Thirteen species mostly of lesser known timbers and four species of bamboo were shipped to Germany for quick seasoning, chemical treatment, and conversion into chipboards. The processed materials, comprising impregnated timber and treated bamboo, chipboards and prefabricated wall units and bamboo mats, were used in constructing two sample houses and one bamboo hut on the grounds of the Government Timber Depot, Ahlone, Rangoon.

The results in Germany had shown : (a) possibility of quick drying of Burmese timbers without much degrade at high temperature and high velocity air circulation, (b) capability to absorb adequate quantities of chemicals necessary for durability and (c) suitability for conversion into chipboards.

A semi-commercial plant provided by FAO for quick seasoning and impregnation has been installed and arrangements are under way for test running, training of personnel for operation and future expansion, and small scale production of housing timber to accelerate rehabilitation.

A drive has been made to expand the Government Wood Workshop on sound commercial basis for mass production of furniture required by government departments as one of the Agricultural and Rural Development Corporation's activities.

(iii) *Fuel wood*—Wood fuel and charcoal continue to be the two forms of fuel abundantly and generally used in Burma.

The proposed briquetting of charcoal dust will depend on the availability of a suitable and economic binding material.

(iv) *Minor products*—An implementation programme has been drawn up recently for :—

(1) Development of turpentine and rosin extraction.

(2) Development of the collection and processing of lac.

(3) Improvement of the utilization of the mangrove.

6. Timber production

(i) *Standardization and grading*—All teak exported from Burma are graded under the old established rules known to the market. There is, however, no written grading rules for other hardwoods in the sense they exist for teak, and marketing is generally on buyers' specifications.

Burma is examining the proposed FAO Standard Grading Rules for other hardwoods consultation with the trade.

(ii) *Requirements and supplies*—The domestic and export requirements of teak and ther principal hardwoods tend to increase, and efforts are directed towards this end.

The Forest Department is organizing to link up the main roads with all potential working areas freed from insurgents by motorable feeder roads to enhance forest output and the State Timber Board has purchased one large capacity saw-mill (its third) and is completing the installation of another. These four mills will have an annual capacity of 125,000 tons.

7. Education

(i) *Higher Education*—Recruitment for training at the University of Rangoon for both the Forest Department and the State Timber Board continues according to plan.

Promising officers and science graduates are also sent abroad

(ii) *Training of forest rangers and deputy rangers*—The training of forest rangers and deputy rangers at the Burma Forest School continues.

The State Timber Board has decided to send their *Chaung-oks* (equivalent in grade to the deputy rangers) for training to the same school.

The construction of the Forest Rangers' College at Maymyo replacing the Burma Forest School is being handled by the Special Projects Implementation Board recently formed by the Union Government.

(iii) *Training of labour for forest and wood industries*—Training schemes initiated by the Forest Department, State Timber Board, Rehabilitation Board and the Artisan Training Centre continue.

(iv) *Propaganda*—Radio talks and participation in various shows and exhibitions are regular features. The Burma Forest School Museum has been restored.

The following projects are in progress :—

(1) Filming of 'The Forests and Timber Industries in Burma'.

(2) Translation of forestry subjects for use as text-books and general reading matter.

(3) Inauguration of the World Festival of Trees.

(v) *Recreational woodlands, national parks, etc.*—The following developments indicate the trend of the increasing recognition of the need for formation and maintenance of such nationally desirable estates as recreational woodlands, natural parks, etc. :—

(1) Tree planting work undertaken in their estates by various authorities and boards with the assistance of qualified forestmen.

(2) Re-organization of the game preservation branch by the Forest Department.

(3) Formulation of projects on development of "The Union Botanical Garden near Hlawga lake, north of Rangoon", and "The Model Arboretum at the Cantonment Gardens, Rangoon", by the Agricultural and Rural Development Corporation.

8. Research and Statistics

(i) *Research*—A project for the establishment of a Forest Research Institute has been drawn up and approved by the Union Government. It will deal with both forestry and forest products. This Project is being handled by the Special Projects Implementation Board.

(ii) *Statistical organization*—A Central Statistical and Economic Department was formed in 1953 under the Ministry of National Planning for collection of production and price statistics for all items of commodities including timber and timber products.

9. Conferences

The following departmental conferences were held during the 5-year period 1948–49 to 1952–53 :—

Conservators' Conferences – 1948, 1949, 1950, 1951 and 1953.

Divisional Forest Officers' Conference – 1953.

10. Conclusion

It is almost a century that the Burma Forest Department has existed holding stewardship of the invaluable teak forests under scientific management. It may be a short period in the forest sense but the record of steady progress towards attainment of an ideal must be a source of satisfaction to all foresters past and present.

The department sustained a heavy loss in the retirement of British officers on Independence. A new chapter has opened. Recruitment and training programmes are in full swing. The fresh spirit is vigorous ; with good wishes, it will be our endeavour to be worthy of the high tradition acquired by the Service.

This issue has been printed on paper from Sabai grass (*Eulaliopsis binata*) prepared on the pilot plant of the Cellulose & Paper Branch, Forest Research Institute, Dehra Dun.

FORESTS OF HYDERABAD STATE

BY D. RAI, B.SC. (WALES)
Chief Conservator of Forests Hyderabad (Deccan)

Summary—The Forest Department was created in 1867 A.D. It remained under non-technical Heads for 44 years during which period some of the important species were declared Reserved. "Reserves" were exploited by means of rated permits issued to contractors. In 1912 A.D., the Department was reorganized and forest areas were selected for reservation. The present policy is to improve the existing 12,172.84 square miles of forests, mostly confined to the eastern half of the State and reclothe the eroded, treeless western half by anti-erosion and afforestation methods and thus increase the present 14.9% area of the forests to 33%.

1. History and Constitution of the Forest Department

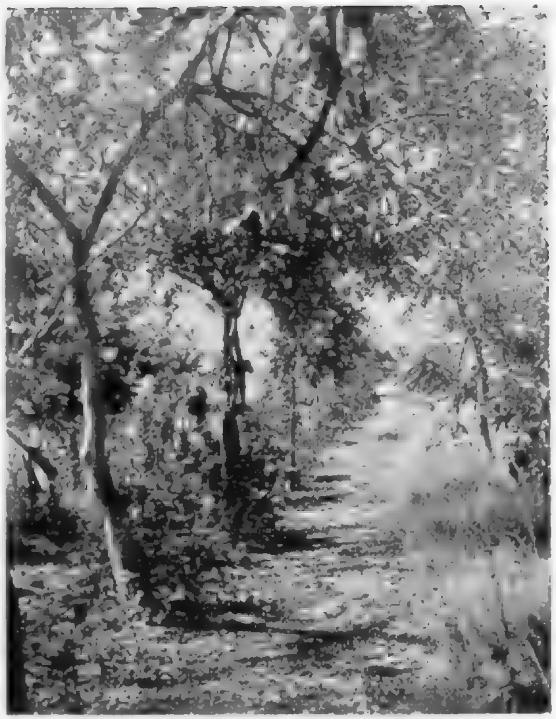
The Forest Department was created by Sir Salar Jung on the 16th July 1867. It remained under the control of officers who had no technical forest training for 44 years. During this period valuable species of the forests were declared 'Reserved' and the department's duty was to protect and extract only these ; the remaining species as well as their produce remained under the control of Revenue Authorities. This duel control resulted in the clearing of large wooded tracts for the extension of cultivation.

In the year 1912 the Department secured the services of Mr. F. A. Lodge, I.F.S. (retired Conservator of Forests, Madras Presidency). During the short tenure of his office, a Forest Code was prepared, certain areas were brought under systematic working along with the reservation of important forest tracts, the Department was reorganized into Forest Divisions which were placed under two Circles (Eastern and Western) each in charge of a Conservator, and the entire Department under an Inspector-General. After the retirement of Mr. Lodge, the Department again came under the control of a non-technical head and remained so for nearly 17 years. This long period in the history of the Forest Department was spent in convincing the then Government of the necessity of forests in the economy of a country and in stressing the need for a change of the policy of clearing wooded areas for cultivation and colonization. Mr. Mason (the then Inspector-General of Forests to the Government of India) was invited in 1933 to advise in formulating the State's forest policy. After an intensive tour, he pointed out that—

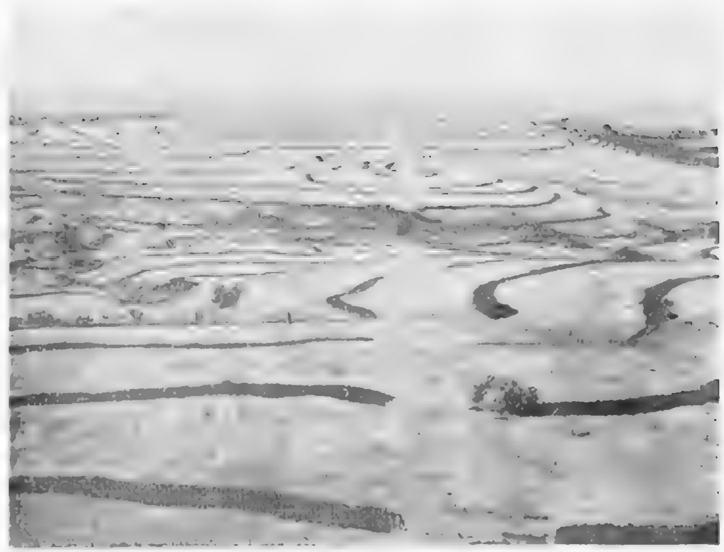
> "The future policy of the Government will aim at avoiding premature dis-afforestation and reserving as quickly as possible all forests suitable for conservancy".

Mr. Mason was invited again in 1937 to study the progress made. Meanwhile the long spell of non-technical shepherding of the Department had been broken and a general forest consciousness had been roused. During the Second World War most of the areas under systematic working had to be worked in advance to meet the war demands, for which the post of a Forest Utilization Officer was created.

In order to build up the forest resources, specially after their exploitation in advance during the War, the State formulated a Post-war Forest Policy on the lines of the Indian Post-war Forest Policy of Sir H. Howard. This policy was still in its infancy when in 1947 and after, great political changes took place. Hyderabad was merged in the Indian Union ; this was followed by the merger of *jagirs*, *paigahs*, etc., in the State itself. From 1948 to 1950 communist menace appeared in its crudest form, so much so that in the worst effected parts even the normal work of the Forest Department was at a complete standstill. Some of the



Afforestation in Hyderabad—Trench Sowing is a successful method; a plantation raised by this method.



Contour trenches made for afforestation purposes.

forests of the Telangana zone were illicitly felled by the *ryots*; in order to curb communist activities, large clearances were made all along both sides of the main roads and railway lines. These deviations from the normal state of affairs made the Department to chalk out a more rigid forest policy so as to cope up with the altered conditions. Soon after the undersigned took over charge as Chief Conservator, this policy was drafted keeping in view the general policy of the Central Government. The gist of the formula is as follows :—

> It deals with increasing the forest area by taking under control even small bits of tree clad or scrub lands in the treeless zones of the State and in special cases to acquire and reclothe badly eroded lands in order to save the adjoining agricultural fields. The forests which are not under systematic management are to be brought under regular Working Plans. All merged lands are to be linked with the existing Divisions and brought under regular Working Plans. Additional Divisions will be created if warranted.

Two new Divisions were created, i.e., Adilabad and Palwancha and a third working plan party was formed.

Structure of the Department

The present structure of the Department is as follows :—

CHIEF CONSERVATOR OF FORESTS

Technical Assistant	.. 1
Attached Officers	.. 2
Forest Utilization Officer	.. 1
Flying Squad Officer	.. 1

Conservator of Forests, Northern Circle	Conservator of Forests, Working Plans Circle	Conservator of Forests, Southern Circle
Divisions	*Divisions*	*Divisions*
1. Asifabad*	1. Silviculturist	1. Warangal*
2. Mancherial*	2. Afforestation Division Hyderabad	2. Khammam*
3. Nirmal*	3. Afforestation Division Bidar	3. Palwancha
4. Adilabad	4. W.P. Party No. 1, Mahbubnagar	4. Nalgonda
5. Nizamabad	5. W.P. Party No. 2, Palwancha	5. Mahbubnagar
6. Nanded	6. W.P. Party No. 3, Warangal	6. Karimnagar
7. Aurangabad	7. Superintendent, Forest School, Yellandu	7. Gulbarga
8. Medak		

* Sub-D.F.O.'s of Assistant Conservator's rank are attached to these Divisions.

Topography, Physical Features and Climate

The area of the State is 82,168·3 square miles. It lies between 15° 10′ and 20° 40′ North latitudes and 74° 40′ and 81° 35′ East longitudes ; the average altitude is 1,250 feet above mean sea-level with a few peaks rising from 2,500 to 3,500 feet. It is naturally divided into two large and nearly equal zones linguistically as well as geologically ; the Western half of the State known as Marathwada overlies Deccan trap, while the Eastern half known as Telangana is composed of Archean gneiss.

The climate is hot and dry. The average annual rainfall varies from 23 inches in the south-western parts to about 50 inches towards north-east. Maximum temperature in summer rises even up to 120°F. in some parts ; the minimum in winter is 58°F.

Forest Types and Resources

The forests of the State belong to the dry tropical type in which dry teak, mixed deciduous and thorn sub-types are met with.

Along the river Godavari and within its watershed, on well drained soils, *mixed teak forests* are found presenting good straight growth ranging from 50 to 80 feet in height and from 3 to 5 feet in girth at breast height. The main species is teak with its associates *Terminalia tomentosa, Hardwickia binata, Diospyros melanoxylon, Adina cordifolia, Lagerstroemia parviflora, Pterocarpus marsupium* and *Terminalia belerica.* The understorey usually consists of *Holarrhaena antidysenterica* and species of *Grewia* and Gravinlonsis, etc. Sometimes the undergrowth consists of Bamboo (*Dendrocalamus strictus*) to the exclusion of all other vegetation.

This type on alluvial and dry shallow soils consists of an open crop of miscellaneous species containing varying proportions of teak (from practically nil to 25% or more) with an average height of 20 to 40 feet. This type is common both on trap and sandstone formations.

The undergrowth consists of various grasses. The trees found are *Tectona grandis, Terminalia tomentosa, Anogeissus latifolia, Lagerstroemia parviflora, Acacia catechu, Lannea grandis, Buchanania latifolia, Bassia latifolia, Phyllanthus emblica, Boswellia serrata, Sterculia urens* and *Zizyphus* sp. In its southern spread this type merges in the Krishna catchment area forming the forests of Krishna Basin. Here *Hardwickia binata* is the main species associated with *Anogeissus latifolia, Diospyros melanoxylon, Terminalia tomentosa,* etc. Along the western side of the State *Santalum album* is found associated with thorny species like *Acacia arabica, Acacia sundra, Randia dometorum, Cassia fistula, Albizzia amara, Chloroxylon swietinia, Azadirachta indica, Aegle marmelos, Limonia acidissima* and *Feronia elephantum.*

Percentage of Forest Area

The following statement shows the area under different classes of forests and the percentage of forest to the total area of the State.

Area of the State	Area of reserved forest	Area of proposed reserve forest	Area of protected forest	Area of unclassed forest	Total of 2–5	Percentage of forest to the total area of the State
in square miles						
1	2	3	4	5	6	7
82,168·3	6,114·53	2,526·23	2,162·88	1,369·20	12,172·84	14·91%

From the above statement it will be clear that the proportion of forest area to the area of the State is much less than what is actually required.

Classification of forests according to their utility

From the point of view of yield, the land under forest can be broadly classified as follows :—

		square miles
(*a*)	Timber (large and small) producing areas	4,100
(*b*)	Scrub forests (including fuel, grazing grounds and grasslands) ..	5,000
(*c*)	Hill forests. (These forests are not worked at present as a protective measure against erosion)	3,072
	TOTAL ..	12,172

Working Plans

Out of the 16 Divisions, Working Plans for six divisions, were prepared and sanctioned by the Government. These divisions have now been brought under regular working. Three more Working Plans have been recently completed and are awaiting Government sanction. Three Working Plan parties have already started field work in three more divisions. Apart from the Working Plans now mentioned, various schemes have been drawn up for Soil Conservation, anti-erosion and afforestation works for the treeless tracts. Foreshore plantations and irrigation plantations under the Tungabhadra projects as well as village plantation schemes have been submitted. They are under the scrutiny of the Government.

Forest area under sanctioned working plans is 5,294·32 square miles; area under sanctioned felling schemes is 1,325·48 square miles and under sanctioned provisional schemes is 1,764·12 square miles. Thus the total area under regular management is 8,410·92 square miles or 60·9% of the total forest area.

Revenue

The Revenue of the department for the year 1953–54 is as follows :—

A.

		Rs.	as.	p.
1.	Major Produce (timber and fuel)	42,98,630	3	4
2.	Minor Produce (Bamboos, *beedi* leaves, grass and grazing)	32,69,226	10	2
3.	Miscellaneous (compensation, etc.)	5,57,102	2	6
	TOTAL ..	81,24,959	0	0

Expenditure—The expenditure under different heads is as follows :—

B.

		Rs.	as.	p.
1.	Establishment and Contingencies	23,77,700	14	1
2.	Conservancy	2,76,166	3	5
3.	Development	2,50,860	5	4
4.	Miscellaneous	2,05,742	1	1
	TOTAL ..	31,14,469	7	11
	Net income =	50,10,489	8	1

Percentage of expenditure to income is 38·33 and that of Conservancy works out to 3·4 only.

Condition of Regeneration – Natural and Artificial

Due to fires and over-grazing, natural regeneration by seed is not at all satisfactory whereas coppice regeneration is also defective owing to the stock under felling being unsound and overmature. In order to obtain natural regeneration and assist it artificially rigid fire protection is being enforced, specially in timber producing areas, by converting Felling Series lines and Compartment lines into Fire Lines and by adopting artificial plantings in patches and in groups. Under the Second Five-Year Plan, the Department is laying greater stress on building up of forest resources by adopting large scale plantations.

Silvicultural Problems and Research

The main problem of the Department is to convert the forests into normal stands in the shortest time possible for which three parties are engaged in drawing up adequate Working Plans taking into consideration the following facts.

1. Artificial regeneration wherever it is necessary, with special attention to high potentiality areas.
2. Soil Conservation works in eroded zones by anti-erosion and afforestation methods.
3. Aiming at sustained yield without jeopardizing the growing stock.
4. Providing adequate protection to hilly areas and restricting the felling operations to cultural requirements only.

The Silviculture Branch of the State was reorganized under the First Five-Year Plan and is actively engaged in determining the best method of afforesting eroded lands and in selecting suitable species for this purpose. Contour trenching technique has been developed and various factors involved in its operation are being investigated. Nursery and experimetal garden experiments have been started and the study of growth of various species and their phenological behaviour have been undertaken. Various pamphlets and booklets have been prepared, some of which are under print. A revised Forest Flora of the State has been published.

Extension of forests

According to the policy explained above the western half of the State, which is almost devoid of forests, and where the prevalence of famine and water shortage conditions are almost an annual feature, extensive operations have been undertaken to afforest them under the First Five-Year Plan. So far 14,371 acres have been successfully afforested. On lands where formerly nothing used to grow, grass is now coming up profusely and seedlings of hardy fuel species have established themselves in the trenches. Some seedlings of 1951–52 have even attained heights of 6–9 feet.

Under the Second Five-Year Plan, impetus has been given to these operations in almost all the districts of this zone, cultural operations in the existing forests, artificial regeneration in fuel and timber forests, irrigated plantation in the commanding zones of projects such as Tungabhadra, etc., survey of minor forest produce of the State, bringing into limelight inferior species by seasoning and preservation, survey of medicinal plants, establishment of forest-product-based cottage industries such as lac, apiculture, sericulture and *katha* manufacture, etc., organization of intensive research, establishment of village forests, publicity and propaganda with a view to creating mass forest consciousness.

Soil Conservation Research Centre

In order to study the Soil Conservation problems in *morrum* tracts, Sahibnagar area has been selected as a Research Centre where work of determining the rate of wash-off of surface soil, suitable species for afforesting these tracts and investigation in different methods of afforestation and study of ecological succession has already been started by the State Forest Department on a modest scale. This Centre will be developed fully in course of time; the Central Government has promised to subsidize it.

Wildlife

The fauna of the State is represented by tiger, bear, panther, *sambhur* deer, blue bull, spotted deer, *Chikara*, antelope, etc. Among rare animals are bison and wild buffalo. Due to indiscriminate shooting and unsportsman-like slaughter in the past, most of these animals are becoming rare. In order to preserve them the following game sanctuaries have been established :—

	Name	Area in square miles
1.	Pakhal game sanctuary ..	339·0
2.	Eturnagaram game sanctuary ..	313·8
3.	Pocharum game sanctuary ..	50·0

The Hyderabad Wild Animals and Wild Birds Protection Bill and Rules have been drafted and submitted to the Government. This enactment as well as the existing game sanctuaries and a few more that are being proposed to the Government will provide ample scope for the rehabilitation, protection and propagation of wildlife. Establishment of a National Park is also contemplated.

Conclusion

The Forest Policy of the State has been implemented to a great extent under the development plans. Efforts so far made are bearing fruit and a bright future is in store for the forests of the State.

PROGRESS OF SILVICULTURAL RESEARCH IN INDIA

BY K. KADAMBI

Central Silviculturist, Forest Research Institute, Dehra Dun

Summary—**The history of the Silviculture Branch of the Forest Research Institute has been traced. Problems of Silvicultural Research have been analysed and progress under each indicated. Future lines of research have been touched upon.**

The Silviculture Branch of the Forest Research Institute, Dehra Dun is the chief medium through which information on the results of Forest Research in general and Silvicultural Research in particular is disseminated to foresters all over India and to some extent also to neighbouring countries. The Central Silviculturist initiates co-operative research on problems concerning several States and lays down the lines of such research. For this purpose he keeps in touch with the forest problems of all Indian States, watches the progress made in forestry in every part of the world and makes knowledge of such progress available to the States.

History of the Silviculture Branch, F.R.I.

The Branch which started its life in 1906 remained more or less static till the appointment of R. S. Troup three years later. Troup held the post for five years and after him came successively – H. Howard, E. Marsden, H. G. Champion, M. V. Laurie, A. L. Griffith, Jagadamba Prasad, M. S. Raghavan, V. S. Krishnaswamy and the writer. It was Troup who actually laid the foundation of systematic research in this field. He laid out Sample Plots for determination of crop increment and Experimental Plots to study Silvicultural problems. He investigated methods of artificial regeneration. His monumental work "Silviculture of Indian Trees" is well known. In Troup's time there were no Silviculturists in any of the States. Marsden continued Troup's work. Separate Silviculturists were appointed to Burma in 1916 and Uttar Pradesh in 1918; Bengal, Madhya Pradesh, Assam, Punjab, Madras, Bihar and Orissa followed one by one. Recently the erstwhile princely States of Travancore-Cochin, Mysore and Hyderabad have also established separate offices for silvicultural research. Howard succeeded Marsden. Sample plot work expanded and got standardized during his time, and yield and single tree volume tables were compiled for even-aged crops of *chirpine*, sal (Coppice and high forest) deodar and sissoo. Experimental work was gradually relegated to Provincial Silviculturists. Champion succeeded Howard in 1926. Yield tables were compiled by him for *Pinus excelsa* and *Quercus incana* and also multiple yield tables for deodar, the first of their kind produced in India. Volume tables were also compiled for a number of trees. An Experimental Manual was published in 1931 and also a new Statistical Code. Methods of experimental work were standardized, thus making it possible to tackle investigations on common problems on a co-operative basis. Champion and Trevor also wrote a Manual of Indian Silviculture.

M. V. Laurie and A. L. Griffith came in respectively after Champion in 1937 and 1941. During their period a number of problems connected with the artificial regeneration of teak and the dry fuel forests of Madras State were tackled and yield and stand tables for teak (1940) and sal (1943) and standard commercial yield tables for teak in Madhya Pradesh (1942) were prepared. Progress was recorded on the usefulness of partial enumerations in irregular crops. The "Manual of Silviculture" by Champion was revised.

Griffith was succeeded by Jagadamba Prasad (1947), M. S. Raghavan (1949), V. S. Krishnaswamy (1951) and finally the writer (1954). This period saw the initiation of

instruments for recording daily diameter and girth increments of trees, popularising the Unimeter – a multipurpose field instrument which does the combined work of Clinometer, Ghat Tracer, Optical Square, Dumpy and Abney Levels, etc. A yield table (for two thinning intensities) was prepared for teak and a volume table for *khair*. Genetical experiments were started and air layering was tried out successfully on several trees, notable among them being *Casuarina*. The most recent achievements of the Branch include finalizing of a method for control of *Loranthus* and one for inducing heartwood formation in sandal trees. A method to control fungus diseases is under way and useful results are emerging especially on the fungal disease of *Bauhinia variegata*. A method of vegetative propagation – namely grafting the stem of a sapling on the root of another of allied kind, is also being developed. Genetical studies on twist in *chirpine* were resumed and the results indicate that twist can probably be recognized even in the germinating stages of the seedling when its cotyledons unfold.

Staff

The Silviculture Branch was expanded by the appointment of a Soil Chemist in 1939 and an Ecologist in 1948. The former has studied mainly the problems connected with the deterioration of soils under pure teak, mortality of *Casuarina* in the coastal sand dune plantations of Madras and the cause of fertility of Rajasthan desert soils ; he has also standardized the method of examination of soils under field conditions and co-operated in the preparation of a soil map of India.

The Ecologist deals with ecological problems. He is engaged in successional studies of conifers in the Himalayan region and various other problems bearing on forest ecology like studies on forest humus, foliar ash contents of leaves and the like.

The All-India Silvicultural Conferences

In recent years the research programmes of the Silviculture Branch of the Research Institute and those of the States is chalked out periodically at the Silvicultural Conferences where these are discussed on the basis of research papers contributed by the delegates of various States of India. The growth of silvicultural research in India is, therefore, closely linked with these Conferences. In the first Conference of 1918 details of the methods of collecting growth statistics were discussed and computation work was standardized. The second (1922) Conference decided to introduce "Howard's System of Ledger Filing" of forestry literature and regulated the working relations between the Central and State Silviculturists. The third Conference (1929) discussed the methods of experimental research, importance of seed origin, problem of pure teak plantations and thinning research. At the fourth Conference (1934) – artificial regeneration of irregular, uneven-aged crops, mixtures in plantations and the technique of plantation work were discussed. The fifth Conference, convened at the beginning of the second World War in 1939, stressed the need for co-operative research on major problems which concern several States, discussed subjects like artificial regeneration with the Selection System, statistical methods in irregular crops, erosion and forestry, soil problems, etc. The sixth Conference (1945) was held to ascertain the effects of the second World War on Silviculture and forestry and to determine what research was urgently needed on problems arising out of the War and the projected post-war schemes. The seventh conference (1946) dealt with the organization of post-war silvicultural research, technique of soil erosion surveys, efficiency of enumerations, *Casuarina equisetifolia* plantation technique and such other problems. The eighth and latest conference (1951) covered a wide field of subjects. The highlight of this conference included the decision to replace Howard's ledger filing system by the Revised Oxford System, laying emphasis on the need for studies on forest tree genetics and the dire need for

augmenting the staff of the Soil Section of the F.R.I. to speed up studies on soil problems and the need for setting up of volume tables for important forest trees.

Problems and Progress of Silvicultural Research

Five main types of problems face a Silviculturist in India : (i) Natural Reproduction, (ii) Artificial Regeneration (afforestation), (iii) Growth factors including those of Plant Physiology and Ecology, (iv) Growth Statistics and (v) Tree Genetics.

Natural Regeneration

In the early years of Indian Forestry the tendency was to imitate European methods of management. This proved successful for the *chirpine* (*Pinus longifolia*) forests of the Himalayas and the coppice forests of the plains, but failed in the case of blue pine (*Pinus excelsa*) in pure crops, *deodar* (*Cedrus deodara*) in many localities and Himalayan spruce in most places. Sal (*Shorea robusta*) in the moister localities and better quality soils, and teak over much of its range have also presented problems. So, too, in certain localities *Bombax malabaricum* has proved difficult to regenerate naturally, as also various other species of the tropical evergreen and semi-evergreen forests of Assam and Andamans.

In the Himalayan coniferous forests, some success has been obtained with the natural regeneration of deodar and mixed regeneration of blue pine, silver fir and spruce but in the case of over-mature forests the problem remains practically unsolved. Disturbance of the surface cover of humus so as to expose the mineral soil below and allowing more light on the soil are believed to help. Sal has failed to regenerate in the moister type of sal forests (not in the drier ones or in hill sal) in which general protection including fire protection has been given. Work during the last four decades involving manipulation of top canopy shade, suitable conditions of ground cover including shrub cutting and burning, general protection from grazing, frost, etc., have proved to be of limited usefulness. A Symposium on the subject held last year has, among other matters, drawn attention to the need for experiments on soil working and manuring and recommended also the replacement of the Uniform by Irregular Shelterwood System of Working for sal forests.

Natural regeneration of teak has not attracted much attention because this tree has proved exceptionally easy to raise artificially. Here, again, in the moister types of deciduous forests teak fails to regenerate naturally. A rigid fire and general protection has made matters worse. A fairly satisfactory technique has been evolved in the relatively dry type of teak forests of Central India to help the natural regeneration lurking beneath the undergrowth of bamboo to develop into a nearly pure crop of teak, but this method has only helped what regeneration was already there to establish itself ; its ability to induce the coming in of fresh regeneration is still doubtful.

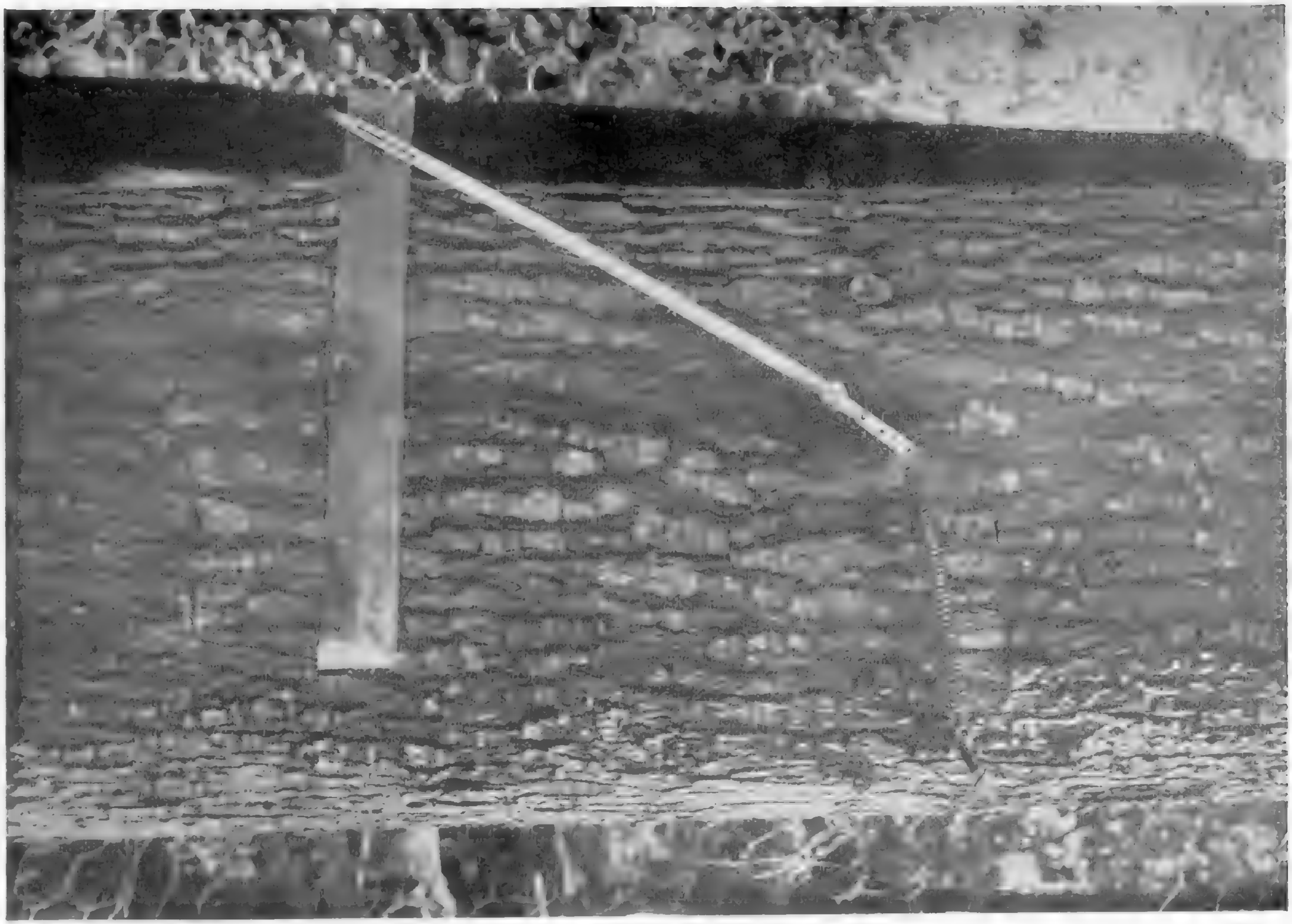
As regards evergreen forests, it is now generally known that manipulation of the upper canopy layer to open it out like a sieve to let in just enough light for the seedlings and saplings of evergreen tree species to thrive *without permitting the competing, more light loving weeds to grow is* the best method.

Artificial Regeneration

In the case of teak all outstanding problems on artificial regeneration have been practically mastered as a result of stump planting so that, given suitable locality and soil we now are in a position to raise plantations with almost cent per cent success. Other localized methods like the "*dona* technique" which showed promise are now being more or less replaced by stump planting. It has been shown that economizing is possible in nursery stock by

The Silviculturists' Laboratory, Germinated Shed and Hot House, Forest Research Institute and Colleges.

The introduction of suitable exotics into the Country is one of the main duties of the Central Silviculturist Exotics in their germination and seedling stages seen in the Research Garden, Forest Research Institute and Colleges, Dehra Dun.



A very simple equipment for measuring *daily* girth increment in trees, Silvicultural Research Garden, Forest Research Institute and Colleges.

planting teak stumps split length-wise. The advantage of increasing the planting distance in the best quality soils of Madras from 6 to 8½ feet has been demonstrated.

Plantation work has now gradually spread to many species, including *Gmelina arborea*,, *Chukrassia tabularis*, *Phoebe goalparensis*, *Michelia champaca*, *Alnus nepalensis*, *Morus laevigata*, *Cryptomeria japonica*, *Bombax malabaricum*, *Evodia roxburghiana*, *Ailanthus excelsa*, *Broussonetia papyrifera*, *Hopea parviflora* and others.

Sal and the taungya method—Artificial sowing has become the standard method of establishing sal, and in recent years sal *taungya* has become very common. Stump planting of sal has also been tried with some local success. The *taungya* method, which means raising of forest crops in conjunction with agricultural crops, is the most significant development in tropical forestry and an important contribution which India has made. The advantage of the method lies in the better growth of the forest crop obtained in the fully cultivated and well weeded soil and the very great reduction in the cost of plantation formation. Many important species have been raised by *taungya* including *Dalbergia sissoo*, sal, teak, *Kydia calycina*, *Acacia catechu*, *Acacia arabica*, *Bombax malabaricum* and bamboos.

Casuarina equisetifolia—The technique of forming *Casuarina* plantations along the sea-coast of Bombay and Madras and elsewhere on the tableland of Mysore was standardized. Investigations have been carried out on the minimum quantity and frequency of watering for plants (a costly item) during summer. Noteworthy in this connection is the "*Planting Brick Technique*" (Proc. VII Silv. Conf., 1946) successfully developed in afforesting the inland sand dunes of Talkad in Mysore State which eliminates the need for artificial watering of *Casuarina* seedlings planted on the burning sands, thus greatly reducing cost, yet increasing the survivals.

Growth Factors including Plant Physiology and Ecology

Tree phenological and microclimatic studies have been in progress mainly at the Forest Research Institute for some time and useful results have been recently published. Noteworthy is the recently started study of sub-soil and aerial temperature variations under forest and in the open by means of thermocouples. In the field of Soil Science study of desert soils have yielded fruitful results. The correlation of tree species with the conditions of the soils on which they grow and the underlying parent rocks has been attracting increasing attention in recent times.

Growth Statistics

Thinnings—Comparative studies have been made of the different methods of thinning which call for a high standard of technique and uniformity of treatment, and it has been ascertained that in the case of teak in Nilambur thinnings can begin very early and the first two thinnings can be mechanical; a thinning cycle has been evolved for that locality. Craib's advance thinnings, to anticipate not *follow* suppression, has been applied to teak with success ; it was found that wood of fast grown teak trees from Craib's plots is not inferior to other plantation grown teak wood. Thinning research has been started in various other species including *chirpine*, sal and deodar.

Sample Plots and Linear Increment Plots—The history of the development of the technique of sample plots has already been dealt with. There are nearly 2,000 sample plots scattered over the forests of India whose results are being compiled at the F.R.I. Sample plot technique, standardized a long while ago, is being improved in some of its details. A very recent line of development in this work, namely study of soil and light intensity in sample plots is under initiation.

Statistical research in irregular crops which had remained backward has received an impetus with the laying out of Linear Increment Plots from the early thirties. Recently an

attempt has been made to determine the balance in the distribution of the number of trees in the successive diameter classes as determined by the law of De Liaquort.

Tree Genetics

Studies on vegetative propagation—Very little work has been done on this subject in India. The recent beginnings made are significant ; these include research on the vegetative propagation of tree species by means of air layers, the most notable success being on *Casuarina equisetifolia, Terminalia myriocarpa* and *T. arjuna*, experiments on inarching, success having been obtained on *Pinus longifolia*, successful "Branch grafting" of teak and the novel "Root grafting" work of various trees including *Broussonetia papyrifera* on mulbery roots and vice versa, *Gmelina arborea* on teak roots, *Eugenia jambolana* on Eucalyptus roots, toon on *Chukrassia tabularis* roots and vice versa.

Seed origin—Co-operative investigations on the geographical races of teak are being run in eight Indian States. Similar work on high resin yielding capacity strains of *chirpine*, races of *Schleichera trijuga* and *Butea frondosa*, and inheritance of figure in *Terminalia tomentosa* are being done on a small scale.

Other items of Research

Fire protection—For some years past early burning, by which is understood a deliberate letting in of a quiet fire through the forest undergrowth which is advantageous in keeping out very harmful fires later on has been practised. Controlled burning is being practised in moist sal forests to keep them from progressing to the climax and for checking the undergrowth, a factor advantageous to natural reproduction. In some moist teak forests of Madhya Pradesh, burning has been considered to have similar advantages.

Control of Loranthus—The most recent researches in the Silviculture Branch, F.R.I., have evolved a simple and cheap method of eradicating from *toon, sissoo* and other trees this phanerogamic parasite some species of which have wiped out plantations in Bengal and Madras, and are causing extensive damage to valuable fruit and forest rees in orchards and plantations. There are also promising indications of fungi being controlled by similar methods. (*Ind. For., Aug.* 1954)

Browsing—Browsing damage by *sambhur* and *chital* have brought forth measures to erect game-proof fencing, which is being done on a large scale in some places. Ditch fences and electric fencing have also been tried.

Sandal Heartwood Formation—Sandal tree planted outside its natural home is stated not to produce scented wood or to do so only indifferently. Such trees (12 years old) growing in New Forest have been successfully induced to produce heartwood by injecting into them various chemicals. If confirmed, these results will enable one to make the tree yield scented wood at his bidding.

Desert Research—A Desert Research Afforestation Station has been established in Rajasthan to check the advance of the Rajputana desert by forming shelter belts of trees one behind the other, each 5 miles wide and about 400 miles long. Sowing of seed of hardy tree species like *Prosopis* spp. and others from the air by aeroplanes has been tried in this connection to cover large areas with seed in a short time.

Systems of Forest Management and Forest Inventories—The earliest system – Selection System – as practised in India, was a "mining method" in which exploitation was confined to marketables ; this has gradually given place to one requiring great professional skill. The systems Simple Coppice and Coppice with Standards, also copied from Europe, have yielded to the more rational "Coppice with Reserves" in which immature poles are not sacrificed and

valuable trees of Minor Forest Produce value are also saved. The Madhya Pradesh method of releasing suppressed teak regeneration has been already referred to. Clear-felling *cum* artificial regeneration has spread to many tree species and is being practised especially in mixed forests containing derelict crops. The Shelterwood System, which has greatly extended in to the moist sal forests of Uttar Pradesh and elsewhere has been found wanting, and is due to be replaced by Irregular Shelterwood. "Aided natural regeneration" which had been in vogue in some *Terminalia myriocarpa* and other forests of Assam is now being replaced by methods which are more or less wholly artificial. What is known as "*diffuse planting*" which is really "advance canopy underplanting of teak stumps" practised in parts of Bombay and Madhya Pradesh have shown increasing usefulness. Such advance planting is believed to be specially useful before a gregarious bamboo flowering for securing teak regeneration in such areas. In evergreen forests where the canopy has been badly opened up as a result of heavy exploitation, "lifting" of the canopy in stages combined with selective tending has been shown to be a possible method of natural regeneration. Artificial regeneration of the dry fuel forests of Madras by sowing or planting in *rab* lines and *rab* patch-plantings of teak and miscellaneous trees in the teak pole forests of Kanara, Bombay have been developed.

Enumerations

The strip enumeration of Brandis' days has continued to persist in the enumerations of irregular crops. It has been shown that in irregular crops partial enumerations are quite efficient in giving adequately precise estimates of the growing stock and that though random sampling is to be preferred in its own way, systematic sampling from a random start has distinct advantages of its own. A method of systematic sampling, known as "Spot Method" in which the samples consist of circular plots uniformly distributed all over the sampled area was first tried in 1936–37 and found more advantageous than the "Sampling Strips" under certain conditions (*Ind. For.*, 3, 1943). In the hills large sampling areas, extending over a whole compartment, have been tried.

Formerly all working plans were scrutinized and sanctioned by the Inspector-General of Forests but with the transfer of the forest administration to the States this fell into abeyance. The Central Silviculturist continues to help the States with information on latest statistics and yield calculations. Working Plan control has greatly improved. Working Plan Manuals were prepared for some States notably – Punjab (C. G. Trevor), Uttar Pradesh (A. E. Osmaston), Bihar, Orissa and Mysore (K. Kadambi).

Conclusion

Progress of Forest Research has to go hand in hand with the increasing multiplicity of problems arising out of a more intensive utilization of forests. It may be said that, inspite of the set back suffered by the two World Wars, a marked all round progress has been achieved : (1) in the natural regeneration technique of evergreen forests, (2) in the development of artificial regeneration of teak and sal, the latter especially by *taungya*, (3) evolution of silvicultural systems more suited to Indian forest conditions, (4) standardization of working plan technique, (5) development of more appropriate methods of working plan enumerations, (6) more efficient working plan controls and, (7) improvement of research methods to solve the complex silvicultural problems associated with forestry.

FORESTS OF JAMMU AND KASHMIR

BY HARNAM SINGH PATHANIA
Chief Conservator of Forests, Srinagar

Summary—The Department, first organised in 1891, is manned by trained foresters. Kashmir contains the finest forests under Himalayan conifers, the easier ones are managed successfully under he Uniform System and the balance under the conservative Selection System. Regeneration is satisfactory except of fir due to grazing, and of *chir* due to incendiary fires. Willow plantation has been successfully raised. Soil erosion is a problem and efforts are afoot for tackling it.

The State is rich in medicinal herbs. Drug farming has recently been started. The industries, run successfully, are Rosin and Turpentine and Kashmir Willows. The State is rich in wildlife and is world famous for trout fishing and big game hunting.

General outline

1. This State, situated at the extreme N.W. corner of India, comprises the uppermost drainages of the Indus and Jhelum rivers, middle Chenab and western Ravi. The country is generally very mountainous, with elevations ranging from 1,000′ at the foot of Siwaliks to K2 (28,250′) the second highest peak in the World.

Historic back ground

2. The present State was carved out a hundred years ago out of a conglomeration of small principalities that then existed in this hilly country and came into being as a result of the Treaty of Amritsar (1846) when the Kashmir Province was also included in the domain of Maharaja Gulabsingh, the ruler of Jammu. The two frontier districts of Gilgit and Ladakh were annexed subsequently by conquest.

Origanization

3. The Forest Department, as a separate entity, was first organized in 1891 by Mr. McDonell, I.F.S. ; when territorial units were differentiated, coniferous forests demarcated, fire conservancy introduced and laws and rules enacted. Two re-organizations, necessitated by the expanding activities of the Department, followed in 1924 and 1942, so as to bring the administration in line with other adjoining Provinces. As at present, under the administrative control of a Chief Conservator there are four Circles (2 territorial, one each Working Plan and Research and Soil Conservation and Forest Industries), 22 Divisions and 72 Ranges. The total operative strength (exclusive of areas under occupation) stands as :—

CCF. (1), CF.'s (4), DFO.'s and their gazetted Assistants (30), Rangers (117), Foresters (275) and 1,247 Forest Guards.

4. All forest officers down to Forest Rangers are trained at the Forestry Colleges, Dehra Dun or in foreign universities. Foresters and other subordinates are being trained since 35 years at the local Forestry School.

Rainfall and climate

5. The outer Himalayas receive a fair amount of summer monsoons, which, however, are spent up by the time they penetrate the Kashmir Valley or the inner regions, where the chief

Deodar (*Cedrus deodara*). Regeneration Fellings under Uniform System. (Kashmir).

Deodar (*Cedrus deodara*). Regeneration fellings under the Uniform System. (Kashmir).

Deodar (*Cedrus deodara*). Regeneration fellings under the Uniform System. (Kashmir).

Kail (*Pinus excelsa*). Regeneration fellings (under the Uniform System). Zawra (Kashmir).

precipitations are during winter in the form of snow. The months of March–April are usually the rainiest. This is a definite advantage for regeneration of conifers. The Indus Valley is a vast barren, highly mountainous country with little or no rainfall.

6. The climate varies from hot summers to pleasant winters in the Siwaliks or outer regions, and pleasant summers to severe winters in the Kashmir Valley and other localities above 5,000 ft. Ladakh district is extremely dry and cold, but the climate is less rigorous in Gilgit lower down the Indus. There are no forests in the Indus drainage.

Forest types

7. Kashmir forests consist mainly of the west Himalayan conifers, i.e., deodar (*Cedrus deodara*), Kail or blue-pine (*P. excelsa*), silver fir (*Abies pindrow*), Spruce (*P. morinda*) and *Chir* (*P. longifolia*) and their associated broad-leaved species like walnut, maples, bird-cherry and ash. West-Himalayan oaks are confined to outer monsoon regions. These forests belong to the following distinct forest types :—

(*a*) Sub-tropical (pine, and dry).
(*b*) Temperate (both moist and dry). These are the most important.
(*c*) Alpine – high-level pasturages.

Area

8. The following statement gives an idea of area under forests :—

(*a*) Total area of the State 84,471 sq. miles.
(*b*) Forests 11,057 ·5 sq. miles (demarcated 10,170 ·9 sq. miles, partially demarcated 754 ·1 sq. miles and undemarcated 132 ·5 sq. miles).
(*c*) This works out to only 13% of the total State area, but to 52% for the Jammu and Kashmir Provinces alone.
(*d*) Area covered by proper working Plans 6,280 sq. miles.

The forest

9. There are no reserved forests in Kashmir and all forests, unless specifically closed, are open to grazing and other concessions. Even so, the protection afforded to these forests in the earlier stages of forest conservancy and administration, when the incidence of grazing was perhaps not as heavy as now, has had a very wholesome effect. Masses of young poles of deodar and blue-pine 50–70 years old have established as a direct result thereof.

10. Considering their quality, density condition of advance-growth and accessibility, deodar-pine and fir forests of Kashmir are perhaps the finest in the whole of the Union. *Chir* forests are limited in extent and are of minor importance, except that those occurring on the Siwaliks are tapped profitably for resin. Bamboo (*Dendrocalamus strictus*) is confined to a small unit – Jasrota (6 sq. miles). Scrub forests, wherever they exist, have no direct economic value except to continue as protection against erosion.

Working Plans

11. To start with from 1891 only dead-wood fellings were executed. Later on working plans were made for important units only, prescribing the Indian Selection system for the more important forests and Improvement Fellings for the other less important ones. Between 1923–32 all important forests were brought under regular Working plans. These are revised every 10–20 years. There are two separate divisions under the Working Plans and Research Circle to carry out this work.

System of management

12. Most of the deodar-kail and fir forests are on comparatively easier ground. Advance growth, especially of deodar and pine, is in abundance. Trevor's Kulu plan having led the way, and the Kashmir forests being most suited for it, conversion to uniform under the Shelter-wood compartment system (Punjab Irregular) had been adopted for all the easily accessible forests, as also for *chir* forests. On difficult country in the Kishenganga, Chenab and elsewhere modern selection system was introduced. Yields based initially on partial enumerations were pitched rather high. This omission has now been rectified by complete enumerations and estimating conservative yields after excluding increment as a safeguard.

Regeneration

13. As a result of protection afforded soon after the creation of the Department even-aged crops of young deodar and Kail have come up on extensive areas. Kail has also been colonizing all blanks. Best deodar regeneration is in evidence on soils resulting from mica schists where regeneration of deodar presents no problem. In the case of fir very good regeneration (30–60 years old) exists along the northern slopes of Pir Panjal. But younger regeneration is deficient as also elsewhere in the State, as a result of over-grazing by buffaloes and goats. *Chir* regeneration is very unsatisfactory on account of the difficult country and frequent incendiary fires, necessitating change over to cautious Selection-cum-Improvement fellings.

14. Due to optimistic or too theoretical approach some initial mistakes were committed, e.g., in selecting areas usually the best and devoid of advance-growth for regeneration fellings and over-calculation of yield as a result of partial enumerations. Natural regeneration could not keep pace with fellings, especially when good seed years of deodar occur at intervals of 4–5 years. This necessitated artificial restocking by sowings and plantings. Some very good work has been done in this respect in Kashmir. The initial set-back has now been overcome by taking advantage of the advance-growth at the time of subsequent revisions. Regeneration of fir forests after fellings under the Uniform system has been scanty due to insufficient funds for the disposal of debris or working of the humus, as also heavy incidence of buffalo grazing. This has necessitated reversion to less exacting or more conservative fellings under the Selection System.

Exploitation

15. The system of exploitation has all along been through contractors' agency who obtain forest lots by competitive tenders and make their own arrangements for conversion, transportation and marketing. The Forest Department exercises necessary check and control. Departmental operations were tried as an experiment during the twenties but were given up subsequently. The system of sales is that of carrying out the markings under the prescriptions of working plans and selling different lots on a lump-sum basis. This is working satisfactorily.

16. The timber trade suffered a very serious set-back as a result of partition and subsequent invasion when Kashmir lessees suffered heavy losses, estimated at about two crores. The Kashmir Government took a very bold step in sanctioning concessions in royalty totalling 111 lacs and affording other facilities, thereby rehabilitating this trade.

17. The total estimated yield of all species combined is 220 lacs c. ft. standing (deodar 58, *kail* 45, fir 112 and *chir* 5). The volume sold during 3 years prior to raids averaged 175 lacs c. ft. No sales were possible in 1947 and 1948. Subsequent sales have averaged 140

lacs c. ft. The average revenue and expenditure figures for these periods in round lacs of rupees are :—

		Rev.	Exp.	Surplus
(*a*) 3 years before raids	..	106	26	80
(*b*) 2 raid years ..	..	29	20	9
(*c*) 5 subsequent years	..	52	27	25

During 1953–54 Revenue realizations were 74·3 lacs and expenditure 31·3 lacs and surplus 43 lacs.

Plantation

18. The Department has successfully raised willow plantations (*Salix alba* and *S. fragilis*) on marshy land or marginal areas reclaimed along the Woolar lake. These plantations are worked under a system of clear-fellings with artificial restocking by means of planting big stout cuttings 8 × 8 feet apart, supplemented by coppice where it does come up. The rotation is fixed at 16 years. The total commercial area is only 10,860 acres.

Silvicultural problems

19. The main problems that the Kashmir forester has had to face in managing this fine property are :—

(i) *Diseases—Areceuthobium* is killing a lot of *kail* especially in higher localities. In mixture with deodar, kail is being fast replaced. *Tremetis* on *kail*, which even attacks deodar in some moist localities is a more serious problem. Removal of all mature trees or those apparently attacked during the course of fellings, major or improvement, is being resorted to as the only practical solution.

(ii) Fires in the *chir* forests which some times extend into important deodar-pine forests as well. A system of fire-lines to separate the latter and departmental controlled burnings are being introduced.

(iii) Grazing especially by buffaloes and goats. This is problem No. 1 that has baffled solution so far.

(iv) Illicit damage which in the form of lopping is directly responsible for the fungus on pine.

(v) Pohu (*P. jacquemontana*) inhibiting deodar regeneration. Cutting of the underwood for fuel or charcoal is reducing the incidence, although the problem is not completely solved.

Research

20. A Forest Research Division was created in 1929 for conducting sample plot field-work for the compilation of deodar-kail yield tables at the Forest Research Institute. During recent years it has taken up experiments on natural regeneration of deodar and fir, collecting statistical data, on the farming of important medicinal plants, or any other silvicultural problems, in consultation with Dehra Dun.

Soil Conservation

21. Soil erosion is a very serious problem in the State especially in the outer Siwaliks where scrub forests could not be demarcated in time and have been ruthlessly destroyed.

Browsing by goats or grazing by heavy cattle are creating further complications. Elsewhere, defective methods of cultivation on sloping ground without terracing is responsible for not only washing off of the rich top-soil but for silting up of the Jhelum, resulting in floods. The State has enacted a Soil Preservation Act on lines of *Chos* Act in the Punjab but its enforcement has not yet been possible to the desired extent, until the people are properly educated against the ravages of soil erosion and the grazing incidence is controlled.

22. The areas under forest are generally immune from this menace, except in high-level pasturages that are heavily grazed where serious erosion has already started. The Department had taken up demonstration areas for afforestation since 20 years and a good headway has been made. Cost is low, Rs. 5–20 per acre, where people co-operate ; but where large scale fencings have to be done to exclude grazing, the cost works up as high as Rs. 80–100 per acre or even more.

23. Under the National Extension Scheme, soil conservation operations have been extended over larger tracts, i.e., the problem areas. In some places spectacular results have been obtained but progress is slow elsewhere. It has amply been demonstrated, however, that if grazing could be controlled and browzing excluded from the Siwaliks no large-scale contour trenchings are necessary and sufficient cover can be created within a short time of 5–10 years.

Minor Forest Products

24. Many valuable medicinal plants and drugs are found wild in Kashmir forests. Of these important ones like aconites (*Aconitum heterophyllum*), belladonna, colchicum, ephedra, *Podophyllum* and Kuth (*Saussurea lappa*) are collected departmentally, cleaned, sifted and standardized and then sold in the market or to the Drug Research Laboratory. Digitalis and Pyrethrum have also been grown successfully. In the wild state it has not been possible to control the alkoidal contents and therefore drug farming on a moderate scale by the Forest Department but more extensively by the Drug Research Laboratory has been taken in hand during recent years. *Artemisia maritima* is collected and processed into santonine by a local firm who hold monopoly for this drug.

Industries

25. The following industries are working under the direct control of the Forest Department :—

Jammu Rosin and Turpentine Factory—The Department collects fifty to sixty thousand maunds of resin per annum from *chir* pine which used formerly to be sold to the Jallo factory near Lahore. Since 1938–39, the Department has a factory of its own, started with an initial block capital of 3 lacs and run on purely commercial lines. It has a capacity to distill about 60,000 maunds per annum with an annual turnover of 12 lacs. The factory has paid back the investment 6 times over.

26. *Kashmir Willows* (for Cricket bat manufacture). Kashmir has a virtual monopoly of willows used in the manufacture of cricket bats. A factory was started in 1938 and taken over by the Forest Department in 1942. With an initial capital of 1·5 lacs, this concern has also been run very successfully. The yearly turnover is over 2½ lacs of rupees and the investment has been paid back in interest and profits 3–4 times over. It is intended to expand this factory to include other sports goods.

27. *Small Scale Forest Industries*—This was started in 1951 for the manufacture of stationery articles and pencils. It is still in the initial stages but has a promising future.

The Government have also set up a big Joinery Mill near Srinagar for the manufacture of doors and windows and this is just going into production.

Wildlife

28. And last though not the least is the variety of fauna and wild game for which Kashmir is world famous since over half a century and is verily a dream of all anglers and sportsmen.

29. Trout was introduced in the beginning of this century. In this line Kashmir affords some of the finest fishing sport for anglers and attracts visitors to Kashmir. Two hatcheries are maintained for stocking up the streams and for limited sales. Good *Mahasheer* fishing is available on the Jhelum, in Ningle and Tangrot.

30. Of game birds, partridges and jungle fowl are found along the Siwaliks and the pheasants, *kalij*, *koklas*, *chir* and *monal* higher up ; as also *tragopen* and finally the *ram-chikor*. But the best sport is afforded by the *chikor* especially in the Valley and the duck and geese which haunt the lakes and game reserves during the winter months. Snipe is found in abundance both during autumn and early spring.

31. It is, however, big game for which Kashmir is famous, especially the frontier districts of Ladakh. The Kashmir Stag (*hangul*) is found only in Kashmir. This majestic deer has attracted many a world renowned big-game hunter to this part of the world.

32. Of wild goats, *markhor* is either found on the Panjal range (Poonch, Kazinag-Shamshberi) or Astor and Gilgit. Ibex is more numerous, chiefly in the Baltistan, Ladakh and Warwan. Wild sheep (*Ovis*) are confined to the frontier districts : sharpu in Baltistan, bharal in Ladakh and the ammon in extreme north-east (Damchuk-Chengchanme). It is on these high-level plateaus, bordering Tibet that the Tibetan antelope and gazelle are also found.

33. Black bear and leopards are plentiful and declared as pests. The snow-leopard is becoming rare and found only in the frontier ; Thar is abundant in *Kishtwar* and *Goral* is common in the lower Himalayas. Brown bear is met with along the higher forest limits – best places are Gurez and Warwan. Serow is not plentiful and is protected.

34. Game rules and fisheries regulations have been in force since fifty years. These have now been consolidated into proper Acts and extended to the whole State. Provision under the act has been made for game reserves and sanctuaries wherein either very limited shooting is permitted or none at all. Yet, much requires to be attained in the line of preservation of the varied fauna in the State. The best protected units are the State Rakhs which are administered by another sister Department of the State.

35. Game and Fisheries used formerly to be a separate Department but is now a branch under the Forest Department. In recent years protection has become complicated but, with the personnel of the Department spread over the whole State, better results are expected to be attained for preserving this fine heritage. Only recently a Wildlife Board has been constituted which will assist considerably in the preservation of Wildlife of the State.

FORESTS OF MADHYA BHARAT

BY G. S. SONDHI

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Summary—The Madhya Bharat Forest Department, with its numerous problems, came into existence in 1948. The forests are mostly Tropical Deciduous with a variety of forest produce and wildlife. Most of the tree crop is ruined due to over exploitation. New working plans are to be prepared for some forests. The old ones are to be revised on the basis of Silvicultural research. Regeneration is mostly through repeated coppice, with few plantations. The 'Vana Mahotsava' has given impetus to "extension forestry". Soil conservation work is confined to anti-erosion and afforestation works. Uplift of forest village population, particularly Adivasis, is given due attention. Under the Five-Year Plan schemes, the forests are developing all round.

I. General Perspective and organization

The State of Madhya Bharat was formed by the Union of 25 princely States in 1948 As its name indicates, it lies in the central part of the country and is surrounded by the States of U.P., Vindhya Pradesh, Bhopal, Madhya Pradesh, Bombay, and Rajasthan. It covers 46,478 sq. miles of land surface and is inhabited by 79,54,154 persons. The chief source of their livelihood is agriculture, forestry and industries, particularly textile. The State is traversed by the Vindhyas, the Satpuras and the Aravali hills and is drained by the rivers Narbada, Chambal and their tributaries. Agricultural land is fertile. 15,806 sq. miles (34%) of the State area is covered by the Government forests. The forests are in all stages of development from unclassed to Reserved, the latter being worked under regular Working Plans.

Government forests are administered under provisions of the Madhya Bharat Forest Act, 1950, the Fisheries Act, 1950, the Wild Birds and Animals Protection Act, 1950, the Game Act, 1952, and the rules made under them. The National Forest Policy of India, 1952, has been adopted in the State.

The Forest Department, organized in 1948, was re-organized in 1952, on the model of Part 'A' States. For administration, the forest charges are divided into two Circles under Conservators which, in turn, are divided into 8 territorial Divisions, 47 Ranges, 96 Sub-Ranges and 821 Beats. Besides, there is a Forest Education Division and a Silviculture Division. The Madhya Bharat Forest Service contains 27 gazetted officers and the Subordinate Forest Service contains 201 Rangers, Dy. Rangers and Foresters and 1,217 Forest Guards. Forest rights and privileges under the commutation and *haqdari* systems is being brought under a uniform scale compatible with the proper management of the forests. Rules have been prescribed for the exploitation of major and minor forest produce through the Adivasi Co-operative Societies, as far as practicable. Wherever there is keen demand for land for cultivation the blanks in the forests are being reafforested by *Taungya* plantations.

Rs. 50,00,000/- has been provided under the Five-Year Plan for the development of forests.

II. Forest types and resources

The main types of forests in Madhya Bharat are the following :—

(*a*) *Moist-deciduous teak forests* occur in Kathiwar range of the Dhar division where the rainfall is 80–100 inches and the underlying rock is mostly basaltic. These

forests are dense and the trees attain large dimensions. There are numerous associate species. The typical ones are *Tectona grandis*, *Terminalia tomentosa*, *Bombax malabaricum*, *Adina cordifolia*, *Bassia latifolia*, *Anogeissus latifolia*, *Pterocarpus marsupium*, *Lagerstroemia parviflora*, *Dillenia pentagyna*, *Borassus flabellifer*, *Bambusa arundinacea* and *Dendrocalamus strictus*.

(*b*) *Dry-deciduous teak* forests occur in the Indore, Khargone, Kannod, a major portion of Dhar and in parts of Guna divisions. Here the rock is mostly Deccan Trap and the rainfall varies from 25 to 40 inches. The crop is somewhat open on hill slopes and dense in the valleys. The principal species are *Tectona grandis*, *Terminalia tomentosa*, *Terminalia belerica*, *Hardwickia binata*, *Diospyros melanoxylon*, *Anogeissus latifolia*, *Boswellia serrata*, *Acacia catechu*, *Chloroxylon swietenia* and *Dendrocalamus strictus*. These forests yield timber, fuel, fodder grasses, gums, lac, *temru* leaves, *mahuwa* flowers and fruits, tanning materials, *rosha* grass oil, etc.

(*c*) *Dry mixed forests* exist mostly in Shivpuri, Guna, Sheopur and Gwalior divisions, where the rainfall is 20–35 inches and the rock is mainly Vindhyan sandstone and Deccan trap. The forests are open and the trees are stunted and yield poles and fuel. The prominent tree species are *Acacia catechu*, *Terminalia tomentosa*, *Diospyros melanoxylon*, *Anogeissus pendula*, *Lannea grandis*, *Anogeissus latifolia*, *Phyllanthus emblica* and *Terminalia belerica*. They yield small timber, fuel, grasses and other minor produce.

(*d*) *Thorn forests* cover portions of Sheopur and Gwalior divisions. Here the rainfall is 15–25 inches. The rock is hard Vindhyan sandstone. The main species are *Acacia arabica*, *Prosopis spicigera*, *Acacia catechu*, *Balanites roxburghii*, *Zizyphus jujuba*, *Salvadora persica*, *Acacia leucophloea*, *Gardenia turgida*, *Dichrostachys cinerea*, *Capparis aphylla* and grasses. These forests are open and yield fuel, grasses, gums, tanning materials, etc.

(*e*) *Edaphic or seral sub-types* occur locally in the above mentioned main forest types due to special locality factors. They are patches of (i) *Butea frondosa*, (ii) *Anogeissus pendula*, (iii) saline scrub, (iv) *Hardwickia*, (v) *Boswellia* and (vi) dry savannah.

Forest Resources—The State is rich in forest resources. The major produce includes a variety of timbers and woods for fuel and charcoal.

The important timbers are teak, *Anjan*, *Saj*, *Khair* and *Salai*. The "inferior" timber species are *Semul*, *Dho*, *Kardhai*, *Tendu*, *Mahua*, *Arjun*, *Baheda* and *Kalam*. The utility of these species is greatly minimized by their scattered distribution. Crooked, diseased and stunted hardwoods unfit to yield constructional timber as *Dho*, *Khair*, *Anjan*, teak, *Sadar*, *Kardhai* are exploited for fuel wood and charcoal.

Minor forest produce consists of a wide range of useful vegetable, animal and mineral products.

The vegetable products include bamboos and grasses, fibres, flosses, oils, distillation products, tans, dyes, gums, oleo-resins, drugs, edible fruits, leaves and poisons, etc. Amongst the animal products the important ones are lac, honey, wax, horns, hides and bones. Important rocks and minerals are sandstone, basalt, gneiss, granite, slate, limestone, shales, quartzite and ores of iron and manganese.

Schemes have been started to survey, cultivate and utilize the more important economical plant species.

III.—Tabular Statement Showing the State's Forest Areas. (Square miles)

Total area of the State	Forests in square miles							Proportion of forests to total State area (per cent)	Proportion of forests to total State area aimed at
	Reserved	Protected	Unclassed, including inherited ex-private forests	Communal	Municipal	Private	Total		
1	2	3	4	5	6	7	8	9	10
46,478·0	7,384·801	3,451·11	4,970·49	..	..	..	15,805·861	34·00	No change is aimed at.

IV. The status of regeneration – natural and artificial

The forests in the State are nature grown, except for a few patches of artificial growth. Special attention is paid to augment the natural regeneration wherever possible.

Natural regeneration—In the northern divisions the "Coppice with Standards System" and the "Clear-felling System" applied wrongly in the past have resulted in adverse effects on the forest. These are now changed over to "Coppice-with-Reserves" or "Improvement Felling" systems.

In the southern divisions where teak, *anjan* and other mixed forests are found the systems of "Coppice with Standards", "Simple Coppice" and "Clear-felling" have been in vogue. Worked repeatedly on the Coppice systems the crop is showing the signs of deterioration, though there is enough natural seedling regeneration of teak, *saj*, *khair*, *semal*, *salai*, *dho* and others. The *anjan* trees are either coppiced or pollarded but neither method has given satisfactory results.

Artificial regeneration—Artificial regeneration was less resorted to in the past. However, the small scale ravine plantations in Bhind on the Chambal banks, the *taungya* plantations in Sheopur, the sandal plantations in Rajgarh–Narsingarh and teak and *khair* plantations in Kathiwara are coming up well. Increasing efforts are being made for artificial plantations of valuable species, such as teak, *anjan*, *semal*, *haldu*, etc. Lately, experimental *taungya* plantations have been started in most divisions.

V. Silvicultural problems and silvicultural research

In the past, some stray work was done on regeneration and anti-erosion problems; unfortunately the work did not give any conclusive results either due to want of correct procedure or continuity of work.

Wrong treatment has led to depletion and deterioration of the forest crop and degradation of locality conditions. A Silviculture Division has been constituted from 1953 to carry out detailed experiments and observations. A provisional 7-year programme for experimental and statistical investigations has been prepared and is under scrutiny. The main schemes of work are : (*a*) the detailed study of the various forests and their co-relation with the locality factors ; (*b*) silvicultural study of indigenous species ; (*c*) experiments to introduce exotic species ; (*d*) checking of erosion on barren hills and along the Chambal and Narbada rivers and their tributaries ; (*e*) study of grass-lands and their management ; (*f*) collection of statistical data to prepare volume and yield tables, etc.

A few Sample Plots, Linear Increment Plots and Preservation Plots have been laid out. The collection of data for volume and yield tables has been commenced.

VI. Position as regards Working Plans, their preparation and revision

Except for the forests of the former Gwalior, Indore, Dhar and Barwani States, no Working Plans or Schemes exist for the other forests. Working Plans for the former Indore forests need immediate revision. The rest of the forests are managed under the Annual Plan of Operations or Working Schemes. The area under forest working plans and schemes is 6,243·5 sq. miles.

VII. Extension forestry, avenues, canal and village plantations, farm forestry, fuel and fodder reserves

Avenue plantations are mostly confined to cities, towns and their suburbs and are looked after by Municipalities and the Public Works Department. The Forest Department has in its charge a few miles of avenues and around Indore city and Alirajpur town. The Public Works Department has recently started implementing an elaborate avenue planting scheme.

A few acres of plantation have been made in some villages in Gwalior and Bhind areas for fuel and small timber.

The scheme for the creation of village plantations under the Five-Year Plan is being implemented to create fuel and fodder reserves in suitable localities.

Since July 1950, *Vana Mohatsava* is being regularly celebrated with enthusiasm in districts, towns and villages. Every year seedlings and large quantities of seeds of economic value are distributed.

VIII. Production data, marketing arrangements and utilization problems

The yield of forest produce during the year 1952–53 was as follows :—

	Major forest produce	*Quantity*	*Value in Rs.*
		c. ft.	
1.	Timber	5,32,076	22,40,835
2.	Roundwood	6,55,325	11,20,417
3.	Firewood and charcoal	64,37,324	2,64,512
	TOTAL	76,24,725	36,25,764

	Minor forest produce		
1.	Bamboos	36,14,583 Nos.	2,89,676
2.	Drugs	..	1,356
3.	Fodder and grazing	..	14,61,556
4.	Gums and resins	..	2,02,771
5.	Lac	..	5,336
6.	Tanstuffs and dyestuffs	..	31,847
7.	Vegetable oils and oils seeds	..	10,000
8.	Other kinds of minor forest produce	..	5,55,154
		TOTAL	25,57,696
		GRAND TOTAL	61,83,460

Standing timber, poles, firewood, bamboos, *tendu* leaves and fodder grasses are usually disposed of by public auctions. Minor forest produce is collectively auctioned to contractors, mostly Range or Sub-Rangewise. Recently, some fuel and fodder areas were worked departmentally to meet the extreme shortage of fuel and fodder in certain localities. Fuel wood, bamboos, etc., on restricted basis, are allowed to be removed by villagers under licenses. The listed concessionist villagers are allowed to remove from the forests, for their *bona-fide* requirements, fuel, bamboos, grasses, thorns, etc., at concessional rates.

Utilization problems—All forest produce is readily saleable. Scientific utilization of some products is lacking.

For teak, *saj* and other important timbers, seasoning and preservation is being publicized. Softwoods like *semal*, *haldu*, *mahaneem*, *salai* and others are to be put to special uses. Fodder grasses need to be collected and preserved in silage and stall feeding has to be encouraged. The non-fodder grasses are to be utilized for making pulp. Medicinal plants have to be given greater attention. The crude charcoal and *katha* manufacturing processes have to be improved. Large scale production of lac on *ber*, *dhak* and other miscellaneous species has to be undertaken. *Karey* and *salai* for gums and oleo-resin have been worked experimentally and have to be further investigated. Exotics, like *Ocimum kilimandscharicum* for Camphor, Eucalyptus species for oil and fuel, *Acacias* for tannin, etc., need large scale plantations.

IX. Forestry as an agent in soil-conservation

The proportion of forest land (34%) is fairly adequate. In the past ravine reclamation and afforestation works were undertaken in a few hundred acres in the Bhind and Morena districts. The results have been very good in conserving soil and moisture and yields of fodder, fuel and small timber have been obtained from the area.

After the formation of Madhya Bharat State in 1948, soil conservation and land utilization problems are being given due attention. The works include anti-erosion operations, afforestation, reclamation of alkaline soils, improvement of pasture and grass lands. A State Soil Conservation Board has been established for the purpose.

X. Wildlife

The State is rich in wildlife. Amongst important animals and birds are tiger, panther, bear, *nilgai*, Black Buck, *sambhar*, *chital*, crocodile, peacock, the great Indian Bustard and a variety of fowls, partridges, quails, snipes, teals, ducks and geese.

During the time of formation of Madhya Bharat State ruthless poaching and pot-hunting exterminated many animals. The "Grow More Food" campaign added to the heavy toll taken on wildlife. The Government enacted the Madhya Bharat Game Act (1952) and the Madhya Bharat Wild Birds and Animals Protection Act (1952) and framed Rules under them. Under the Five-Year Plan, a National Park and game sanctuaries are being established.

XI. Forest village population

With the proper organization of forests, the Forest Department has to look after the economic prosperity and contentment of the forest village population. Forest produce of an estimated value of more than six per cent of the gross forest revenue is given free or at reduced rates to the forest villagers. The total population of adivasis and backward classes, mostly

living in and about forests is about 15,00,000 persons, which constitutes almost one-fifth of the population of the State. These persons are employed by forest contractors as labourers, or they are engaged in small scale agriculture. The Forest Department has given them various amenities. Contracts of major and minor forest produce are being given to their co-operative societies at concession rates.

XII. The Five-Year Plan

With the introduction of the "First Five-Year Plan" in 1951, the Forest Department in the State inaugurated progressive projects at a total estimated cost of Rs. 50,00,000. The projects consist of forest education, research, and development works such as survey and demarcation of forests, preparation of Working Plans, construction of buildings and roads, tending and protection operations, anti-erosion measures, formation of plantations and forest utilization schemes. The attainments so far are very encouraging.

FORESTRY IN MADHYA PRADESH

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Summary—Madhya Pradesh comprises the former province of C.P. and Berar and fifteen ex-States which merged in 1948. Proprietory rights were abolished in 1951. All forests vest in the State. The land area is 130,272 square miles, 62,400 square miles being under forest. The Forest Department manages 46,803 square miles. It has a Chief Conservator, a Deputy Chief Conservator, five Conservators and 32 Divisional charges. The forest types are mixed, teak and sal. Teak, sal and other timbers, bamboos, lac, *katha*, *tendu* leaves, grazing and wildlife are the important forest resources. A revised forest policy has been formulated in 1952.

Historical perspective

Madhya Pradesh, includes the former Central Provinces and Berar and fifteen ex-States which merged with it in 1948. The Forest Department was established in the year 1862. The forests on the remote hills were mostly unexplored at that time and the accessible areas were being ruthlessly cut. Forests inhabited by the aboriginal tribes were being laid waste by shifting cultivation.

The first Indian Forest Act was enacted in 1865 which enabled the Government to declare lands covered with tree growth as Government Forest and to make rules for their proper management without adversely affecting the existing rights of the people. The Forest Act was revised in 1878. On the recommendation of Brandis, the first Inspector-General of Forests, all forests taken over by the Government were declared as Reserved Forest under the Indian Forest Act. Some (Class I) were in charge of the Forest Department and others (Class II) under the Revenue Department. The policy at this stage was to conserve and extend the reserves of Class I and to manage those of Class II to meet the local demand of small timber, firewood, grazing and other forest produce. Later, in 1886, on the recommendation of Schlich, the then Inspector-General of Forests, all the reserved forests were placed in charge of the Forest Department and the distinction between the two classes of forest was removed.

By the year 1894 demarcation, survey and mapping of most of the reserved forests had been accomplished. In the same year Government of India laid down a definite Forest Policy in their resolution of 1894 which desired that State forests should be so managed as to serve agricultural interests more directly than before and emphasized that the sole object with which they are managed is the public benefit.

Simple working plans were prepared for most of the important forests by the year 1900 which implemented the above general policy. The grazing problem gradually assumed great importance and grazing rules were first made for the Central Provinces in 1915 and for Berar in 1919. From about this time elaborate grazing settlements began to form a part of the revised working plans. An important step forward was taken in 1925 by the establishment of a working plans branch and commencement of proper stock-mapping of the forests. This branch was, however, closed down in the early thirties, but the standard set by it continued to be followed.

The Government ordered a reclassification of the forests for purposes of grazing control in 1933 according to which restrictions, where severe, were removed and the principle of gradual imposition of restrictions was adopted.

As in the war of 1914–18, during the second World War also, the forests supplied very large quantities of timber and other forest produce for defence purposes. As a result, all the working plans were thrown out of gear. After the war, in 1945, a working plans branch was again created as a temporary measure under a separate Conservator. The Circle was again abolished after functioning for about $4\frac{1}{2}$ years and the control of revision of the working plans was given back to the territorial Conservators.

Independence followed the World War II and, during the last few years momentous changes have taken place. A Forest Policy Committee, ordered to be appointed in 1946, was finally constituted in 1948 by the popular Government. Fifteen ex-princely States merged with the former province of C.P. and Berar to constitute the present State of Madhya Pradesh and all proprietory rights (of *zamindars*, *jagirdars*, *malguzars*, etc.), over forest land were abolished in 1951. Thus all forests now vest in the State. The necessity for a revised forest policy was, therefore, obvious and very urgent. Based on the recommendations of the Forest Policy Committee, Government laid down the principles of the revised policy in a resolution in 1952 of which the main ones are as follows :—

> "The main objective to which the management should be directed is public weal. Acceptance of this principle involves the regulation of the rights and restriction of the privileges of user, of individuals or communities in the wider interest of the State and the Nation".
>
> "The necessity for regulating grazing to prevent the forests and pastures from deteriorating and at the same time providing all reasonable facilities to stock owners, consistent with the realization of the special object of management of each class of forests".

The latest policy is being implemented to the maximum extent possible.

Organization of the Forest Department

At present the Forest Department is organized as follows :—

Chief Conservator of Forests .. 1

Deputy Chief Conservator of Forests .. 1

Territorial charges		*Functional charges*	
Conservators Circles	5	Silviculturist and Forest Utilization Officer	..1
Divisional charges	32	Assistant	..1
Sub-Divisional charges ..	24	Working Plan Officers ..	..8
Range charges	208	Foresters Training School ..	..1
Sub-ranges	619	Forest Guards Training School ..	..1
Beats	3,866		

Forest Types

The principal forest types are :—(i) *mixed forests*, (ii) *teak forests* and (iii) *sal forests*. Bamboos occur in all the three types in many places.

The *mixed forests* occur in an extensive area to the east of Nagpur extending as far as Chanda, Raipur and Balaghat in the South, East and North respectively. Another fairly extensive area is found to the west of Pachmarhi extending as far as Itarsi and Amla. The more important and common species found in the mixed forests are *Terminalia tomentosa*, *Pterocarpus marsupium*, *Dalbergia latifolia*, *Adina cordifolia*, *Diospyros melanoxylon*, *Anogeissus latifolia*, *Tectona grandis*, *Bombax malabaricum*, *Boswellia serrata*, *Odina wodier*, *Emblica*

officinalis, *Madhuca latifolia*, *Terminalia belerica*, *Schleichera oleosa*, *Acacia arabica*, *Acacia catechu*, etc., and bamboos.

The teak (*Tectona grandis*) forests which are, in fact, mixed forests in which teak is predominant, occur mainly in the western half of the State. The best teak forests are found in parts of Chanda, Hoshangabad, Bastar and Amravati districts. The species named under mixed forests occur in the teak forests also, but teak is predominant.

The sal (*Shorea robusta*) forests occur mainly in the eastern half of the State. The more important areas are in parts of Mandla, Balaghat, Bilaspur, Raipur, Bastar, Surguja and Raigarh districts. The species named under mixed forests occur in the sal forests also, but they constitute a relatively small proportion of the crop and the percentage of sal is generally very high.

All the above three types have bamboos in many areas which are very important from the economic point of view.

There are some sub-types which are of great economic importance. These may be called :—(i) *Acacia catechu*, (ii) *Butea frondosa*, (iii) *Boswellia serrata*, (iv) *Acacia arabica*, (v) *Zizyphus xylopyra*, etc., sub-types in which the species named predominate.

Forest Resources

The State is quite rich in forest resources. The forests produce teak, sal and other timbers in large quantities as also firewood and charcoal. The best teak of large size has keen demand for ornamental plywood. Sleepers of *Shorea robusta* and other hardwoods are supplied to the railways. *Boswellia serrata* finds use for the manufacture of newsprint. Timber, firewood and charcoal not only meet the needs of the State but are also exported to other States. Bamboos are produced in considerable quantities. After meeting all the needs of the State, a substantial quantity is exported to paper mills in other States and large areas are also earmarked for the two paper mills established within the State.

The forests provide grazing for about a quarter of the total cattle population of the State. In times of need fodder is also exported to deficit States. Thatch grass is extracted for local use. *Sabai* grass is exported for paper making.

Among other forest products of importnce may be mentioned *katha* (*Acacia catechu*), leaves of *Diospyros melanoxylon*, gums, edible fruits and flowers, oil producing seeds, tan-stuffs (myrobalans and various barks and leaves), fibres and flosses.

Among animal products the forests yield hides and horns, bones and fish. Insects produce lac, honey and wax, *kosa*, silk etc.

Wildlife of the State is an asset of considerable importance. Foreign sportsmen are often attracted for *shikar*.

Statement of areas

The following statement shows the total area of the State and the extent of forest areas.

Total area of the State (sq. miles)	FOREST AREA (sq. miles)							Forest area as percentage of total area
	Under the Forest Department				Under Revenue Depart-ment.	Under Corporate bodies	Total forest area	
	Reserved	Protected	Unclassed	Total				
1	2	3	4	5	6	7	8	8
1,30,272	26,191	10,252	10,360	46,803	15,557	40	62,400	47·8%

The area under forest would appear to be adequate for all the needs of the State. But the hilly nature of a considerable portion of the State, deficiency of forests in the large plains of Chhattisgarh, Nagpur and Berar and the demands of other States, clearly point towards the necessity of more forests, particularly in the cultivated plains.

Status of regeneration ; Plantations

Except where adverse conditions, such as excessive grazing, repeated fires, frost, climbers and dense undergrowth exist, the mixed forests regenerate fairly satisfactorily, most of the teak forests of lower quality regenerate adequately and the sal forests regenerate in localized areas moderately. Difficulty is experienced in areas where the adverse conditions prevail in some high quality teak and sal forests, where management prescribes concentrated regeneration operations.

In all forests of lower quality, which are managed under the system of Coppice with Reserves, regeneration is by coppice and regrowth from plants of seedling origin. Well-grown poles are also reserved to form a part of the future crop.

In the teak and sal forests of high quality managed for the production of large timber under concentrated regeneration, coppice and seedling coppice are accepted as reproduction and groups of well-grown poles are reserved to form part of the future crop. Areas where such regeneration is not possible are regenerated by planting in the case of the teak forests. In the sal forests artificial regeneration is not attempted and one has to follow nature.

In all forests managed under systems involving scattered fellings, natural reproduction is depended upon which is variable according to conditions.

Artificial regeneration is also practised in establishing plantations of *Acacia arabica* after clear-felling by agri-silvicultural method. In recent years compensatory plantations of teak and other valuable species, and of soft-wooded species like *Bombax malabaricum* and economic species like *Rusa* grass have been taken up.

The total area of all plantations created in the State is 70·3 sq. miles. At present the area palnted up annually is 1,050 acres.

Silvicultural problems and Silvicultural research

The main silvicultural problems are as under :—

(*i*) Natural reproduction of teak in high quality forests.

(*ii*) *Denovo* reproduction in sal forsests.

(*iii*) Best felling cycle and treatment of bamboo forests for maximum production.

(*iv*) Rehabilitation of large areas of degraded forests.

(*v*) Technique of raising some economic species.

(*vi*) Determination of limiting incidences of grazing in different classes of forests.

and (*vii*) Improvement of pasture in the forests classed as "Pasture lands" and grass reserves.

The Silvicultural branch has had a chequered history. It is inadequately staffed and often other duties are assigned to the Silviculturist. At present the officer is holding charge of the post of Forest Utilization Officer also. The research work that this branch has been able to accomplish is, therefore, limited. At present 138 sample and increment plots are maintained and 52 experimental plots are under observation.

Suitable proposals for its expansion are with the Government.

Position in regard to Working Plans, their preparation and revision

The total area of forest under Forest Department is 46,803 sq. miles. Out of this area, 21,039 sq. miles have working plans or schemes. The forests which are not under working plans or schemes are mainly those that came under the Forest Department in 1948 when 15 ex-States merged with the Madhya Pradesh and the ex-proprietory forests which were handed over to the Forest Department after the abolition of proprietory rights in 1951.

From the year 1945, the Forest Department embarked upon a programme of revision of old working plans and preparation of new ones for the forests recently added. So far 16 working plans involving 14,005 sq. miles have been revised and 7 plans involving 5,760 sq. miles are under preparation. Much work still lies ahead, particularly in respect of the recently acquired areas.

Extension Forestry

In recent years the tree planting festival – *Vana Mahotsava* has given impetus to planting along road sides and in other suitable localities. The sum-total of canal banks suitable for creating plantations is small. On some of them some tree growth is conserved by the Irrigation Department. Lands along the railway lines have not yet received sufficient attention.

As regards farm forestry, the practice of conserving individual trees along field bunds and even on the paddy fields in a large part of the State is noteworthy. One of the important species conserved is *Acacia arabica*. In some ex-princely states there is a practice to dedicate woodlots known as "*Sarna*" to sylvan Gods.

Among the reserved forests, some areas classed as "Tree Forests", most of the "Minor Forests", and all "Pasture Lands" and grass reserves serve the purpose of fuel and fodder reserves. A large proportion of the "Protected" and "Unclassed" forests serve a similar purpose. Judged by area the forests are adequate to meet all the local needs but a large proportion is degraded and their distribution is not as it should be. The extensive plains of Chhattisgarh, Nagpur and Berar have not much forest left. In these plains firewood and fodder reserves are needed to release cattle dung for manure and for more fodder. A scheme is under way to commence work with a view to gain experience.

Production and marketing arrangements. Utilization problems

The annual production of different kinds of forest produce from the forests under the management of the Forest Department at present is given in the following statement :—

Kind of produce	Quantity	Value
		Rs.
Timber	2,33,37,000 c. ft.	1,80,05,733
Fuel	8,05,08,000 c. ft.	69,58,931
Bamboos	5,96,79,711 Nos.	20,57,453
Myrabolans	18,497 Tons	2,16,013
Lac	2,375 Tons	5,61,547
Grazing and Fodder ..	..	39,42,991
Minor Forest Produce ..	..	42,39,146

Various methods are employed for the disposal of forest produce. To meet commercial demands, coupes with standing or felled timber, other forest produce, and depot materials are sold by public auction. Sleepers for the railways, raw materials for certain industries, e.g., paper mills, and the requirements of other Government Departments when supplied departmentally are charged for at negotiated rates. Bamboos are sold against commercial demands by public auctions as well as on rated passes.

For produce with restricted demand and to meet the bona fide domestic requirements of the local people sales are done on rated passes through numerous vendors. The bona-fide requirements of the agriculturists are also met through contractors at fixed rates or departmentally on rated passes. Most of the forest produce, therefore, reaches the markets through contractors or smaller dealers.

For grazing, licenses are issued to individuals. Grass, where there is commercial demand is sold by auction or on rated passes, and by rated passes only to local purchasers.

The greatest handicap in utilizing all the available forest produce is the inadequacy of the railway system, although some roads are being developed. Large areas are still too far away from rail-heads, particularly in the southern and eastern parts of the State. Another handicap is the lack of sufficient industries based on forest produce. Two paper mills have been established recently and there is scope for other industries also, such as bobbin and plywood industries ; and industries based on lac, tanstuffs, geraniol, wastewood, raw hides and bones. The problem is of economical collection at suitable centres.

There is much scope for better and greater utilization of the unpopular timbers by proper seasoning and preservative treatment.

A matter of importance is also the specifications of articles like railway sleepers, electric transmission and telephone poles, etc. Specifications, if so made as to utilize the quality of the materials commonly available with preservative treatment, will help to increase utilization of the timbers.

In the markets although dimensions and qualities are reflected in the prices, there is scope for standardizing sizes and grades.

Forestry as an agent in soil conservation

The catchment areas of the five river systems lie either partly or wholly in this State. A large proportion of the land area is also hilly or undulating. The preservation of sufficient forests and their proper management is, therefore, a matter of vital importance from this aspect as well, not only to this but to the neighbouring States also. This necessity in the wider interests of the State and the Nation has received recognition in the latest policy of the Government. It is resolved by Government that on steep slopes and along river banks "management should aim at rapidly conserving the forests so that they may........exert their beneficial influence on the soil, the water regime and the physical and climatic factors of the locality". Suitable provisions are made in all the working plans or schemes in accordance with the above resolution.

Wildlife

Nature has bestowed upon this State a magnificent asset in its wildlife. The old reserved forests abound in game but the recently acquired areas are generally depleted through the activities of the aboriginals inhabiting them. They are born hunters.

The Government have resolved that "suitable forests of sufficient extent and well away from cultivation should be set apart as Natural Reserves and Game Sanctuaries, and from

forests abutting on cultivation game destructive to life and property should be exterminated". Apart from the National Park and Sanctuaries, considerable areas beyond those abutting on cultivation also hold much game in the old reserves. Excellent *shikar* is provided to sportsmen in many shooting blocks.

Subject to the present policy of the Government wildlife is protected by the Wild Birds and Animals Protection Act (VII of 1912), the Central Provinces Game Act (XV of 1913) and the shooting rules under Sections 26(i) and 76(d) of the Indian Forest Act (XVI of 1927).

There are two National Parks and 23 Game Sanctuaries in the State. The number of shooting blocks available to sportsmen is 536.

The common species of game available are, among animals, tiger, leopard, sloth bear, bison, wild buffalo, blue bull, swamp deer, *sambhar*, spotted deer, black buck, etc. ; and among the birds, ducks, peafowl, jungle fowl, partridge, sand grouse, quail, pigeon, snipe, etc. Some of the game birds migrate after the cold season.

Shifting cultivation

There is a considerable aboriginal population inhabiting the remoter forest areas of the State who practise shifting cultivation. A scheme for settling the aboriginals on lands fit for permanent cultivation is in operation in two forest divisions from 1953. Selected lands are made available by the Forest Department for the establishment of villages. Each householder is granted land by the headman and all materials required for building houses, a pair of bullocks and agricultural implements, and seed for crops of their choice, as free gift by the Government. Food grains are supplied as free gift to each household until the first crop is harvested. Already the response is very encouraging.

Forest villages

There are 1,212 "forest villages" having a population of 1,35,367 scattered all over the forests. These villages afford a permanent supply of labour for forest works.

FORESTS AND FORESTRY IN THE MADRAS STATE

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Summary—The Madras Forests have been under systematic forest management for now nearly a century. Most of the forests are State owned and a well organized State Forest Department, headed by a Chief Conservator of Forests, administers these forests. Correlated to climatic and edaphic variations, six distinct forest types are recognizable, viz., the tropical rains, moist deciduous, dry deciduous, dry thorn, littoral and coastal forests and high level temperate grass areas. Each type is worked silviculturally in the manner most suited to it. A feature worthy of special mention is the extensive plantations of teak (the oldest dates from 1846).

The important timber output is in teak, rosewood, and hardwoods for general constructional and other uses, as also a number of broad leaved softwoods utilized in the plywood trade and the manufacture of matches. The State shares with Mysore State almost a world monopoly in the production of sandalwood. Large areas of the State's forests are utilized for meeting local needs for firewood and grazing. Natural resources in this respect are supplemented by plantations of casuarina in the plains and blue gum and wattle in the hills.

The spike disease of sandal is a problem that has eluded solution for many years. The upgrading of secondary timber species by suitable treatment and seasoning awaits development, as also the improved utilization by medicinal plants and tan substances.

In favourable localities the State's forests abound in a variety of wildlife, a typical locality in Mudumalai being maintained as a Game Sanctuary.

Introductory

1. The Madras State lies in the Southern extremity of India. The region is heavily populated and the main occupation of the people is agriculture. All lands suitable for wet cultivation are utilized intensively for raising rice (the staple food of the people) and all dry lands are extensively cultivated for food crops such as millets and cash crops such as groundnut, cotton, etc. Even on marginal lands, if soil conditions are at all reasonable, fruit gardens of mango, cocoanut, etc., are raised. In the circumstances it should be apparent that forestry has to be confined to lands scarcely fit for any other use, such as sites with shallow or poor soils and remote hilly areas.

2. Generally speaking, the eastern parts of the State is a plains region dotted with numerous hill massifs and hillocks. The western parts include a section of the mountainous country of the Western Ghats and two of their prominent spurs which form the plateaus of the Nilgiris and the Palnis. In both parts, the forests are confined to the hills and hilly tracts and to some small patches of plains wastes near villages. The Western Ghats and the spurs support high timber forests but in the rest of the area scrub forests (valuable for their firewood and fodder resources) predominate.

Historical

3. The full value of the west coast timber forests came to be recognized well over a century ago and systematic management may be said to have commenced with the first efforts in 1846 at raising teak artificially (in Nilambur). The importance of the fuel forests and the need to conserve them (inspite of their intrinsic low quality as 'forests') also came to

be recognized a long while ago. The enforcement of the Indian Forest Act of 1878 (followed by the Madras Forest Act of 1882) accorded a status as Reserved Forests (involving State ownership) to most of the forest areas. Technically trained men came to man a separate Forest Department from earlier still.

Organization

4. The Forest Department serves for the management of over 2,300 sq. miles of timber forests, 2,500 of fuel and fodder forests and 3,800 of sandal bearing areas, under sixteen Working Plans. All the work is directed by the Chief Conservator of Forests, who is responsible to the State Government. The State is divided into 18 divisions (each under a District Forest officer) and these are grouped into 3 Circles, each under a Conservator. The unit of executive administration is the Forest Range, 4–6 ranges being included in a Forest Division. There are, besides, special organizations for the preparation and revision of working plans (under a Conservator's control) and for conducting silvicultural research and experimental work.

Climatic and physical features

5. While the region as a whole is characterized by a warm climate, the geographical features and the characteristic monsoon rains cause considerable variations in the factors of the locality. In the west, the mountains rise to over 8,000 feet elevation with corresponding changes of temperature. The rainfall, derived mainly from the south-west monsoon from June to September, varies from 60 to 300 inches annually. In the rest of the State, the weather is warm and dry most of the year. The rainfall, mainly derived from the less reliable north-east monsoon from October to December, is only 20 to 40 inches.

6. The main parent rock is a gneiss, besides various metamorphic variations of a comparatively basic granite (Charnockite). A feature of the region is the extensive laterization of the parent rock, ascribed to the prolonged effects of a monsoon type of climate. The soil varies from river alluvium and coastal sands to red loam and black cotton soils. Sheet exposures of rock and hard laterite are not infrequent, as also extremely gravelly or bouldery soils.

Forest types, their resources and treatment

7. The floristic composition, therefore, displays great variety. Tropical rains forests, moist and dry deciduous forests, dry thorn forests, mangrove and coastal forests as also high level grasslands all occur in the State.

8. (i) *Rain Forest*—The tropical evergreen or rain forest is confined to the middle elevations (2,000–5,000 feet) in the Western Ghats. The rainfall here ranges from 150–300 inches and is distributed over three-fourths of the year, January to the middle of March alone being the dry period. The temperature seldom rises above 90°F. The forest vegetation usually consists of 3 to 4 storeys and very tall trees with plank buttresses are common. Bamboos are conspicuously absent but reeds (*Ochlandra* spp.) form a common ground cover. Woody climbers, ephiphytic orchids, palms and canes form further features of this type. Although there are numerous tree species, hardly a dozen are of known timber value, such as *Hopea parviflora*, *Calophyllum elatum*, *Mesua ferrea*, *Artocarpus hirsuta*, *Dysoxylum malabaricum*, *Vateria indica* and *Mangifera indica*. The silvicultural requirements of this type have not been fully understood and its management up-to-date is, therefore, limited to an elementary system of selection fellings.

9. (ii) *Moist deciduous forest*—This is economically the most valuable type in the State. It is confined largely to the west coast and occurs at elevations of 1,000 to 2,000 feet. The soil is usually a fertile and deep red loam. The rainfall varies from 60 to 150 inches, distributed over a major part of the year. Temperature rarely exceeds 100°F., though the climate on the whole is warm and humid throughout the year. This type is the natural home of teak (*Tectona grandis*) ; other common timber trees are *Dalbergia latifolia, Terminalia tomentosa, T. paniculata, Lagerstroemia lanceolata, Xylia xylocarpa* and *Adina cordifolia*. There is a fair admixture of *Bambusa arundinacea* in the lower canopy. Climbers are common but neither prolific nor woody. These forests are worked mainly under the Selection or the Clear-felling system. Since 1846, large areas in selected localities (such as Nilambur, Topslip and Wynaad) have been clear-felled and planted successfully with teak.

10. (iii) *Dry deciduous type*—This type is found in the drier localities and extends from the foothills up to an elevation 5,000 feet. The soil is often shallow and the rainfall is comparatively low – 25 to 50 inches per annum. Fires are of common occurrence and the incidence of grazing heavy. The dry season is prolonged and except in the higher elevations (above 3,500 feet) the summer is severe and temperatures even over 110°F. are not unusual. The vegetation consists mainly of medium sized deciduous trees up to 50 feet in height with thorny shrubs in the ground cover. The species generally met with are *Anogeissus latifolia, Terminalia chebula, Tamarindus indica, Albizzia lebbek, A. amara, Strychnos nux-vomica, Melia azadirachta* and *Santalum album*. This type is of primary importance as the natural home of Sandal. These forests are usually worked on a Coppice system, leaving fruit bearing trees such as *Tamarindus*, *Terminalia* and *Strychnos*, and the valuable sandal. Sandal is worked for its heartwood on a physical rotation, only dead trees being extracted.

11. (iv) *The Dry thorn forest*—This type occurs inland on low hills and plains areas. The rainfall is low (20 to 40 inches); most of the year (9 months) is dry; and the temperature rises up to 110° between February and May. The soil, though rich in minerals, is gravelly or stony and often shallow. The incidence of grazing by domestic animals is high. In this dry thorn forest, the crop is open and the trees are small to medium sized, rarely exceeding 30 feet in height, and are armed with thorns. Phyllody is very common. The useful species include *Acacia planifrons, A. latornum, A. leucophloea, Albizzia amara* and *Chloroxylon swietenia*. These forests are worked under the Simple Coppice system on a rotation of 30 years, for providing fuel to the local people. During recent years plantations of casuarina have been extended into suitable sites of this type.

12. (v) *The Littoral and coastal type*—These forests are seen along the river mouths, estuaries or creeks and the sea coast. The water table is fairly high and the water is often brackish or even saline. Periodically, the areas become inundated from the sea. Strong winds are common and the rate of transpiration is high. The soil is either loose sand or a fine clayey mud. The vegetation shows corresponding morphological adaptations to withstand these adverse factors, – such as long tap roots or straggling habit, thick leaves with a reduced number of stomata, pneumatophores and vivipary. The more important trees are *Calophyllum inophyllum, Borassus flabellifer, Rhizophora mucronata* and *Ceriops candolleana*. The areas are worked only for fuel, clear-felling being followed by natural regeneration.

13. (vi) *High level grasslands*—In the Western Ghats and the Nilgiris and Palni plateaus at elevations above 5,000 feet, the vegetation gradually becomes sparse and stunted ; and above 5,000 feet occur extensive grasslands (with small pockets of evergreen forests called *Sholas*). The soil is fairly deep and the rainfall varies from 50 to 100 inches distributed over a period of 9 months. Frosts are common between November and February and probably exercise a major check over the growth and distribution of tree vegetation. The common trees in the sholas are temperate species such as *Eugenia arnottiana, Litsaea wightiana, Michelia*

nilagirica and *Meliosma wightii*. Economically, the sholas are of no value except as protecting the catchments for streams and rivers. But large areas of the grasslands in the upper Palnis and Nilgiris have been planted with blue gum (*Eucalyptus globulus*) and wattle (*Acacia mollissima*) for working on short rotations for fuel and tan bark.

Extent of Forests in the State

14. The total area of the State is computed at a little over 60,000 sq. miles, of which only about 12,150 sq. miles are under forests. Areas under different classes of forests, are as follows :—

State Forests (Class I and Class III Reserved Forests)	.. 8,642 sq. miles
State Forests (Unreserves and Reserved lands) ..	.. 2,508 ,,
Private Forests	.. 1,000 ,,

Thus the area under forests is only 20% of the total area of the land in the State. The distribution of forests over the different parts of the State is not uniform either, there being a greater concentration of forest areas in the west. An increase in forest area to at least 25% of the total State area is aimed at, by transfer to 'forests' of lands not really suitable for other uses and that particularly in districts where the area under 'forest' is deficient.

Regeneration

15. In the evergreen forests, regeneration is mainly natural following on selection fellings. Condition of regeneration is generally satisfactory. However, the silvicultural requirements of individual species are yet to be determined in detail, as also the methods that will lead to an increased proportion of useful species in the crop.

16. In all the accessible parts of the moist deciduous forests, artificial regeneration is depended on, teak being raised wherever conditions are favourable to its growth. There are at present over 27,000 acres of planted teak in the State, some of it in its second rotation. Other hardwood plantations extend over some 4,000 acres. In recent years (in recognition of the increasing needs of the plywood and matches industries), large areas are being devoted to raising plantations of broad leaved softwood species such as *Bombax malabaricum*, *Evodia roxburghiana* and *Mangifera indica*.

17. In the dry deciduous and dry thorn areas, up-to-date the method has been natural regeneration from coppice (following on clear-felling for fuel). But it has become apparent that climatic, edaphic and biotic factors are all unfavourable to adequate natural regeneration either from coppice or from seed and that the stand is getting depleted with every cutting. Special measures are afoot, under the Five-Year Plan now, artificially to regenerate these areas at a rapid rate by direct sowings in prepared sites supplemented by transplanting seedlings raised in containers. In the more lateritic soils, the cultivation of cashewnut is envisaged.

18. The natural regeneration of sandal is, however, satisfactory, seedling growth appearing profusely in groups in all sandal areas.

19. In all the State's forests, wherever possible, regeneration is attempted in conjunction with field crops (locally known as the *kumri* method). This enables the forests to be raised at almost no expenditure to the Department and at the same time helps in the additional production of food crops. The cultivator shifts to new areas once the forest tree seedlings are established.

20. In the littoral and coastal tracts, regeneration from seed of the mangrove species is satisfactory. The sandy tracts of this region have been utilized to great advantage by the

establishment of casuarina plantations, the management of which involves clear-felling and re-planting on a short rotation (7 to 10 years). Recently, attention is being focussed also on raising cashewnut plantations.

21. The high level grasslands of the Nilgiris have been successfully afforested with Blue gum (*Eucalyptus globulus*) mainly to meet the fuel demands of the growing hill stations in the region ; but, plans are now under consideration for extending these plantations on a large scale, for such industrial uses as rayon-pulp production. In recent years, these grasslands are also being utilized extensively for raising plantations of wattle (*Acacia mollissima*). The standard practice with blue gum is to put out transplants. Wattle is raised both from direct sowings in cleared lines and by transplanting nursery stock in prepared sites. In the Nilgiri and the Palni plateaus the State now has some 3,000 acres of blue gum plantations and 6,000 acres of wattle plantations ; and plans are in hand for bringing another 15,000 acres under each of these species.

Silvicultural problems and research

22. The spike disease of sandal has for many years remained the most serious problem. This virus disease arrests and stunts the growth, resulting in the formation of brushes of spikes of reduced leaves followed by premature death of the trees. Its ravages have been so extensive that sandal working has for years been confined to the removal of dead trees only, on a 3 to 6-year cycle. Comprehensive investigations for over 30 years have proved of but little practical avail and the problem awaits a fresh approach for its solution.

23. Satisfactory methods have yet to be evolved for regenerating the dry fuel forests of the State, though experimental work on this subject has been in progress for some years. The requirements of evergreen species have also been the subject of silvicultural studies. More recently, the best methods of raising large scale plantations of the exotics wattle and casuarina have been under field investigation.

Working Plans

24. All the Reserved Forests are covered by full scale working plans. A separate Working Plans Circle with a Conservator of Forests in charge ensures the regular preparation and revision of Working Plans and also watches the progress of work from year to year under the various prescriptions of each plan. Ordinarily, working plans are prepared for a period of 15 years and revised by technically trained officers placed on special duty for the purpose. The revision of Working Plans had fallen into arrears during the war period, but efforts are being made since then to clear off the arrears. Meanwhile additional work has arisen requiring the demarcation and assessment of forests taken over by the Department in recent years from large private Estates, preparatory to framing Working Plan prescriptions for them.

Extension Forestry

25. The afforestation of sandy wastes along the coastal tracts and unfertile soils inland with casuarina has been an achievement of great significance to the fuel resources of this overpopulated region. Special measures are being planned now for the rapid rehabilitation of denuded village reserves (*Panchayat* forests) in order to augment the supply of fuel and fodder. Besides fuel species likely to succeed in these inhospitable sites, these measures include introduction of shrubs and trees of value as fodder and green leaf manure, as also the improvement of grass and other ground vegetation.

26. The provision of grazing for the enormous cattle population of the region is a very important function particularly of the dry forests. Up-to-date, grazing regulations have

included (1) limiting the incidence of grazing and (2) planning for deferred or rotational grazing in selected areas. All grazing in reserved forests is regulated by annual permits at nominal rates.

27. The protective functions of forests in river catchments, in mollifying the climate, in regulating stream flow and in inhibiting soil erosion have come to be well understood and considerable stretches of forests especially in the hilly areas are now maintained solely for this purpose, a specific example being the evergreen "Sholas" which mark the origins of numerous streams in the Nilgiris and the Palni plateaus.

Utilization – Production data

28. The average annual output of timber and other forest produce in round figures from the State Forests is shown below :—

	Quantity	Approximate Revenue in Lacs of Rupees
	tons	
Hardwoods including teak ..	35,000	53
Broad leaved softwoods	5,000	3
Sandalwood (Heartwood) ..	900	24
Firewood	90,000	14
Bamboos and Minor Forest produce	..	11

(Note :—1 Lac = 100,000).

Marketing arrangements

29. Teak, rosewood and other hardwoods are generally worked departmentally and disposed of in log form. From the felling site to roadside the logs are dragged by elephants and from there transported by bullock carts or lorries to sale depots. In the case of Nilambur (teak) forests alone, transport to depot is by river, the timber being rafted (with bamboo floats or boats) downstream. Good quality logs are made available to the Public Services such as the Railways, the Defence Department and the Public Works Department. The rest is sold periodically by open auction sales. Conversion to sawn sizes is done by private saw-mills near the main depots. The west coast timber finds markets (transport being by sea mainly) in Bombay, Gujerat, Sind and the countries of the Middle-East.

30. Softwoods used for manufacture of plywood and matches are sold standing in marked lots and are worked by contractors. This variation in procedure is necessitated by the fact that logs of these species are liable to rapid degrade in storage or delays in transit.

31. Sandal trees are uprooted and the entire tree is extracted. The wood is cleaned of all sapwood ; and, the heartwood from the root as well as the stem is grouped in different classes and sold in auction. An elaborate procedure is in force for accounting for the produce, in view of its high value (about Rs. 3,000/- per ton of 2,240 lb.).

32. Fuel forests are worked under a system of clear-felling successive areas annually. The demarcated area is sold standing in open auction to contractors, who work the area for firewood. In view of the danger to the forest from fire, conversion of charcoal in the forests has been stopped now.

33. Bamboos and minor forest produce are collected by contractors to whom the right is leased annually. These produce include wattle bark, Myrobalans, drugs and medicinal plants, essential oils, fibres, flosses, etc. An interesting development recently is the demand for roots of species of *Rauwolfia* found in the west coast forests. The drug is of value in the treatment of high blood pressure.

Utilization problems

34. The evergreen and moist deciduous forests contain a number of secondary timber species which could be upgraded by timber treatment and seasoning. But up-to-date, the Trade has resorted to this but to a very limited extent; however, with the steady depletion of our stocks of large sized teak, this question is assuming importance.

35. The numerous fruits, barks and leaves of Indian trees that could serve to tan hides are under investigation in collaboration with the Leather Research Institute.

36. The codification and cultivation (for intensive utilization) of various medicinal plants awaits attention. A start has been made in collaboration with the Madras College of Indigenous Medicine.

Forestry as an agent to soil erosion

37. The Nilgiris (where land has been opened up indiscriminately for potato cultivation) and the hilly localities in the dry districts (which have badly suffered from excessive fellings and grazing) are threatened with serious damage from soil erosion. Terracing for cultivation with tree planting along streams and edges of terraces, are adopted in the former. Afforestation in conjunction with trenching, is being tried in the latter. Much work still remains to be done to stabilize the soil in these areas.

Wildlife

38. In the State forests are to be found a variety of wildlife, such as the elephant, tiger, bison, ibex, spotted deer, *sambhur*, wild pig, etc. Game Laws are in force to regulate the shooting of wildlife for sport, prescribing close seasons amongst other restrictions. The Nilgiris and the Palni Hills have their own Game Associations, which regulate fishing in the hill streams as well.

39. The State maintains a Game Sanctuary in Mudumalai on the border of the Nilgiris District and Mysore State. The sanctuary has recently been enlarged from 23 to 120 sq. miles. The Department affords facilities to visitors for camping in the sanctuary, for viewing wildlife (from elephant back) and for photographing it.

Conclusion

40. It will thus be seen that the forests of Madras are extremely varied in their nature and contents. They are being managed and worked by the Madras Forest Department to the best advantage of the State and the people of Madras, without in any way jeopardising their perpetuation or their protective functions.

FORESTRY IN MYSORE

BY DR. M. N. RAMASWAMY

Chief Research Officer, Forest Research Laboratory, Bangalore

The Mysore Forest Department is amongst the oldest in India. It had its early teething troubles, being merged with the Revenue (Lands) Department in 1879 but regained its individual identity in 1886 since when progress has been steady. The general tenor from then on has been the gradual transformation of the Department from a purely administrative revenue collecting agency to a technical organization for the conservation, development and extension of forests and manned by a professional service. A visible symbol of the completion of this change was the establishment of the Forest Research Laboratory at Bangalore in 1938. The Mysore Forest Service to-day is amongst the most catholic in the country, its officers having had their professional training at home and in the leading Forestry Centres from all over the World. The Department is headed by the Chief Conservator of Forests, assisted by a cadre of 29 Gazetted Officers and 97 Rangers ; 180 Foresters and 980 Guards look after the protection work of the Forest Estate.

The total area of State Forests and Reserve in Mysore is 5,285·65 sq. miles, all owned by the State and under the control of the Forest Department. This figure includes two patches (some 100 sq. miles) of forest area legally under private ownership but actually managed by the Department. There are no Municipal forests and just a beginning is made to raise Communal forests – locally styled "Village Forests".

The State Forests and Reserves, 5,285·65 sq. miles, form just about 15 per cent of the area of the State. In conformity with the Forest Policy of the Government of India, the target set is to have at least 20 per cent of the land under Forests. It is realized that the implementation of the policy calls for creation of another 1,000 sq. miles of State Forests – a difficult task under any circumstances but almost formidable in the face of the great pressure for more and more land for cultivation. In fact, it would be no easy achievement if encroachments to existing forests are prevented, the standing growth conserved and the quality of the existing forest improved, especially in such areas as were worked heavily to cover Defence needs during the war years. It is also realized that public opinion is of paramount importance in this context and continued efforts are being made to put forth the case for afforestation, the annual *Vana Mahotsava* proving to be of great educative value.

For a State of the size of Mysore (Area 34,000 sq. miles, maximum North-South distance some 300 miles, maximum East-West distance 250 miles), the forest types are unusually varied, the determining geographical features being that the Mysore plateau, some 2,500–3,000 feet above the sea-level (the highest point on the plateau being the 6,500 feet peak in the Bababudan hills) is flanked by the Western Ghats on the West and the Eastern Ghats on the East, the two ranges of hills ("Ghats") coalescing to form the Nilgiri Hills (Blue Mountains) along the Southern border of the State. The North-Western tip of the State is subject to the full blast of the South-West monsoon, the region recording an annual rainfall of some 350 inches. The rainfall decreases rapidly as one moves eastward being reduced to barely 15 inches just about 250 miles away on the eastern borders of the State.

The forest types in Mysore faithfully mirror these large variations of rainfall. The Western Ghats house the tropical rain forests with their closed canopies (*Poeciloneuron indicum*, *Dipterocarpus* sp., *Mesua ferrea*) and several storeys of vegetation interlaced with woody climbers. To the east, through a narrow strip of semi-evergreen, come the moist deciduous forests characterized by teak, *Dalbergias* and the *Terminalias*. These in turn fade and merge

into the dry-deciduous jungles and on to the scrub forests with their *Acacias, Albizzias* and characterstic of the driest regions, *Hardwickia binata.* Particular mention must be made of *Santalum album* which thrives on the Mysore plateau in two broad ribbons ; one, a belt of some 50 miles wide running approximately North and South and a second belt of greatly varying width up to nearly a 100 miles running South-West to North-East of the State.

Steady and sustained efforts have been made to augment the tree crops by raising plantations. The oldest teak plantations in the State date back to 1864. It is reckoned that about every 260 c. ft. of teak harvested calls for replacement by an acre of plantation. This rate of replacement has generally been maintained. Apart from this, the demand for wood fuel from short rotation crops has enormously increased and special efforts are being made to cater on a 5-year plan to this urgent need. The magnitude of the operations involved is indexed by the following figures for 1953–54 : Teak plantings 732 acres, plantings of other species 1,275 acres, Trench mound sowings 938 acres, Replacements 1,211 acres. The figures exclude extensive areas where sandal is raised by dibbling.

These operations present some of the principal silvicultural problems. The technique of teak plantation has been very well developed by stump planting in clear-felled, and burned areas. For fuel crops, *Casuarina* and the *Eucalyptuses* are the favoured species – the principal problems posed being the working of the soil to conserve moisture at economic costs, to shorten rotation and to increase yields. While considerable progress has been made, the last word on the subject has by no means been said. Trench mound sowings have also been developed to raise indigenous species like *Cassia siamea, Pongamia glabra, Albizzia odoratissima, Albizzia lebbeck,* the *Melias* and the *Acacias* predominating. When the moisture economy of the site is less than marginal even for these hardy indigenous species, *Prosopis juliflora* comes in useful. An important but unsolved silvicultural problem is the regeneration of the Tropical Evergreen forests which remained virgin till 1927 but have since been tapped extensively for Railway sleepers and Electric transmission poles.

The guiding principle in the management of the State Forest is to prepare Working Plans, have them sanctioned by the Government and follow the sanctioned Plan scrupulously. This principle has been practised in all the important state forests and, elsewhere, where there are no formal plans, the forests are worked under provisional schemes of management. The position as at the end of 1954 was that 1,341 ·81 sq. miles of State Forests were under sanctioned plans and 730 ·46 sq. miles under provisional schemes – a total of 2,072 ·27 sq. miles. All these plans are, of course, prepared by professional foresters, scrutinized by technical authority and then sanctioned by Government. Thereafter, deviations are not permissible except by special sanction of Government. The plans are revised as per prescription. It may be added that all the plans make the fullest provision to meet in full all the normal needs of the local communities predominately agricultural – for forest produce.

The major wood harvest (this and the following figures relate to the official year 1953–54) consisted of about 1 ·5 million cubic feet of timber, 7,000 poles and *ballies* and 25,000 sleepers. Amongst special supplies were 22,000 c. ft. of mining timber, 90,000 c. ft. of peeler logs for plywood and 9,000 c. ft. of matchwoods. Approximately 1,500 tons of sandal wood were supplied for distillation at the Mysore Governmnt Sandalwood Oil Factory and for the retail sale market. Nearly 6,500 tons of bamboo went in for pulping at the Mysore Paper Mills. 15,000 tons of charcoal and more than 2,50,000 tons of wood fuel fed the Mysore Iron and Steel works. Quantitative data for the so-called Minor Forest Products are difficult to compile but it may be mentioned that the estimated annual production of the famous tanbark "Avaram" (*Cassia auriculata*) is about 8,000 tons. The revenue earned by the Department during 1953–54 was 10 ·1 million rupees.

Sandalwood is a strict State monopoly in Mysore. Timber is marketed through open auction at strategically located Depots. Minor Forest Produce are sold as leases for periods ranging from one to three years in auctions and the successful bidders make their own arrangements for exploitation and marketing. The supply of charcoal and fuel to the Mysore Iron and Steel works is through a departmental agency. In several respects, this supply and its organization are unique because this is the only Iron and Steel works in India consuming wood fuel and not coal. The Mysore Forest Department also operate two saw-mills, a seasoning kiln plant, a wood preservation plant and a small, wood working factory.

One of the principal utilization problems is to ensure the adequate utilization of non-teak timbers. Teak, of course, is internationally famous as one of the finest "all purpose" woods. The public have got used to teak as a "Safe" timber. At the same time, our forests abound in other species whose timbers adequately serve many specific needs for which teak is really not necessary. Fuller knowledge of the properties of these non-teak timbers, development of techniques in using them and, equally important, the education of the public about the many possibilities of these non-teak timbers have all to be co-ordinated in planned development. The "Spike disease" of sandal is a virus infection which is fatal to sandal and is wiping out the crop from large tracts. While a mass of experimental data have been gathered, no method of preventing, or much less curing it, is known. As for Minor Forest Products, we have completed survey of these in the State. This, of course, is just a beginning because the rich variety of our Minor Forest Produce – tans, essential oils, drugs and spices, lac, bamboo, edible products, (which are just illustrative) – pose many problems in their harvesting, storage, processing and marketing.

It is only during this last decade that attempts have been made to educate the public to appreciate the role forests play in Soil Conservation. While no formal survey has yet been made in the State to assess the extent of soil erosion, the areas needing preventive and ameliorative soil conservation measures are increasing – specially in our *Maidan* areas. In view of the large Hydel projects already constructed (Krishnarajasagar, Shimsha, Jog) and planned (Lakkavalli, Honnemaradu), the importance of soil conservation and stream regulation in the catchment areas of our major rivers cannot be exaggerated. Steps have been taken to constitute a State Board for Soil Conservation. Afforestation programmes will doubtless be an integral part of the activities of this Board.

Mysore has been in the fore-front amongst the States in the matter of game conservation, the First Mysore legislative enactment on Game being passed as early as 1901. The finest Game Sanctuary of the State is "The Venugopal Wildlife Park" situated about 50 miles to the South-West of Mysore City. The Park covers an area of 310 sq. miles and within the Park is located the Bandipur Game Sanctuary with an area of 22½ sq. miles. The Wildlife consists of elephant, bison, tiger, panther, wild dog, spotted deer, *sambhar*, mouse-deer, Malabar squirrel and the *langur* ; amongst birds may be mentioned jungle fowl, spur fowl, peacock and green pigeons. The Sanctuary is well served by a network of good motorable roads which criss-cross the terrain and enable wildlife to be seen at virtually a stone's throw. There is a comfortable rest-house and good riding elephants can be provided on requisition to the Mysore Forest Department who maintain the Sanctuary. The Department also conducts periodically the "Kheddahs" – elephant catching operation – which have an international reputation for sheer spectacular appeal. The 1953-Kheddahs resulted in a record catch of 77 elephants.

The Forest Research Laboratory was established in Bangalore in 1938. It is modest in conception and limited in scope. But, it has the distinction of being the first institution in India outside Dehra Dun specially designed and exclusively devoted to work on forest problems.

The Mysore Kheddahs – a herd of Elephants being driven across the river prior to capture.

The Forest Research Laboratory, Bangalore.

This institution has small but well equipped Laboratories for chemical and analytical work on forest products, microscopic, photographic and testing work on timbers, a museum and a 20-acre experimental garden.

Teak, sandal, bamboo, the *Causarinas* and the *Eucalyptuses* are the main forest crops which come within the ambit of forest research in the South. Amongst Minor Forest Products, the tanbarks, essential oils, drugs and lac, amongst others, call for investigation. The Forest Research Laboratory is well located with respect to each one of these. Every one of these is to be found in forests within a 200-mile radius of Bangalore. Many of Mysore's flourishing industries are essentially forest industries – prominent amongst which are sandal oil, plywood, paper, wood distillation products, and lac compositions. For silvicultural work, the principal forest types of South India are within easy reach of Bangalore. Thus, the practical problems of the field and in the factory would leaven Laboratory work. Also, the resources and facilities of many scientific institutions – some of them of an All-India character like the Indian Institute of Science – are accessible to the Forest Research Laboratory.

With so many advantages in its favour, the Forest Research Laboratory, Bangalore, would naturally have a very significant role to play in South India in the plan to establish regional Forest Research Centres in the country to work in close collaboration and co-ordination with the All-India Forest Research Institute, Dehra Dun.

FORESTS OF THE PATIALA AND EAST PUNJAB STATES UNION

BY BALWANT SINGH
Conservator of Forests, Nabha

Historical perspective

The Patiala and East Punjab States Union was formed in 1948 by the integration of the Princely States Patiala, Nabha, Jind, Kapurthala, Faridkot, Malerkotla, Kalsia and Nalagarh. The total land area of the State stands at 10,098 sq. miles. It is inhabitated by 34,93,685 persons giving an average density of 351 persons per square mile.

Organization of the Department

The Forest Department was formed in June, 1949, by integrating the forest areas of Patiala, Nalagarh, Kalsia, Nabha, Jind and Kapurthala States. The biggest share of the forest area was inherited from Patiala and Nalagarh States where the forests are principally situated in the outer Himalayan hills and were managed under regular Working Plans. In the plains a few scrub forests locally called *Birs,* which had been maintained as Game Preserves for the Rulers of the Covenanting States, were integrated.

For organizational and administrative efficiency the department is controlled by a Conservator of Forests, assisted by three Assistant Conservators, one temporary Working Plan Officer and one temporary Assistant Conservator. Three Assistant Conservators and the Working Plan Officer are incharge of four Forest Divisions as under :—

(*i*) Kandaghat Forest Division with Headquarters at Saproon. (Near Solan).
(*ii*) Siwalik Forest Division with Headquarters at Pinjore. (Near Kalka).
(*iii*) Patiala Forest Division with Headquarters at Patiala.
(*iv*) Nabha Forest Division with Headquarters at Nabha.

A trained Fisheries Officer is employed as Assistant Warden of Fisheries under the control of the Conservator of Forests and is responsible for Fisheries Development in the State. All gazetted forest officers and Forest Rangers, Deputy Rangers and half the number of Foresters are technically trained men.

Summary of forest types and forest resources

2. The following five principal types of forest crops are found forming, more or less, pure blocks although associated with scattered trees of other species.

(*i*) Deodar (*Cedrus deodara*).
(*ii*) *Chil* (*Pinus longifolia*).
(*iii*) Oak (*Quercus incana*).
(*iv*) Bamboos (*Dandrocalamus strictus*).
(*v*) Scrub and hardwood species – *Acacia catechu, Acacia arabica, Anogeissus latifolia, Lannea grandis, Dalbergia sissoo*, etc.

(i) *Deodar*—Deodar mainly in pole stage, is the commonest species between 6,000 to 7,000 feet elevation in the Chail and Taradevi Ranges near Simla. It is associated with *chil* in lower parts and on sunny aspects and with broad leaved trees in shady places and cool *nallas*. The area is 2,773 acres,

(ii) *Chil—Chil* is found at its best above 4,000 feet elevation though it extends from elevations of 2,500 to 6,000 feet. It forms pure forests in Kandaghat and Siwalik forest divisions, wherefrom resin is extracted through contractors. *Chil* occurring between 2,500 and 3,500 feet and occasionally at lower altitudes consists of poor quality branchy trees with stunted height growth. The area of *chil* forests is 19,014 acres.

(iii) *Ban oak*—It occurs above the *chil* belt where it forms compact blocks between 5,000–7,000 feet elevation, while at lower altitudes it is usually mixed with *chil* as an under storey and is confined principally to shady ravines and sheltered localities. The area under Ban oak is 9,414 acres.

(iv) *Bamboos*—Bamboo occurs between 2,000–3,000 feet elevations. At lower altitudes it is confined to depressions and shady places. It does not form pure forests to the exclusion of the broad leaved species, but the area where it predominates and is commercially workable is 9,132 acres.

(v) *Scrub and miscellaneous*—The lower zone in the hills and the *Birs* in the plains are mostly covered with hardwood species. In the lower hills, *khair*, *chhal*, *jingan*, *kikar*, *amaltas* and *amla* are found, while in the plains, *kikar*, *beri*, *jand*, *reru*, *shisham* and other miscellaneous trees are intermixed with sprinkling of *dhak*. The approximate area is 70,000 acres. *Bhabar* (*sabai* grass) grows gregariously in considerable areas of the Lower Siwalik Hills and is consumed for the manufacture of paper.

Area

3. The total State Forest area is 171·2 square miles. Private forests in the hills aggregate to 79,296 acres or 123·9 square miles. In addition to this 273 miles of road and canal side avenues are under the management of the Forest Department.

The area statement is as under :—

Total area of the State	Forest area			Proportion to State area of the existing forests	Proportion aimed at
	State	Private	Total		
	(Square miles)				
10,098	171·2	123·9	295·1	2·9%	5%

Status of regeneration, natural and artificial

4. The conifer and broad leaved forests in the hills are intercepted by villages and cultivation and are burdened with the rights of local people under the provisions of Forest Settlement except over an area of 5,428 acres which is recorded as free of rights. Rights of felling trees for firewood, building timber for marriages and other ceremonial occasions, lopping for fodder and grazing and grass for cattle, way for man and animals are exercised by the right-holders. Natural regeneration in forests open to rights is, therefore, obtained principally under Selection and Improvement fellings, while in oak and scrub forests which are free of rights, under the Coppice with Standards system.

The natural regeneration in deodar and *chil* areas, where fires have created blanks, and in oak forests, is on the whole satisfactory, while in scrub forests which are coppiced, the reproduction is not satisfactory. Although forests in the plains are free of rights, grazing is permitted on payment of fee according to past practice. Natural regeneration is, therefore, highly deficient. *Kallar* patches are almost blank.

In the pre-integration period sowings and plantings had been done on a very limited scale mainly due to paucity of funds. Large scale afforestation measures are now undertaken principally under the Development Plans. The success achieved is fairly satisfactory, especially so in the denuded hills of the Siwaliks.

In the plains, regular irrigated plantations of *shisham* and mulberry are being raised over 4,000 acres by clearing the present miscellaneous scrub growth.

Silvicultural problems and silvicultural research

5. Advantage has hitherto been taken of the silvicultural research carried out at the Forest Research Institute, Dehra Dun and the experiments made in the Punjab. Research in silviculture has not been organized locally in the past, nor is there any immediate necessity for the same.

There is no special silvicultural problem worth mentioning.

Working Plans

6. Out of total Government Forest area of 1,10,993 acres, 85,884 acres are being managed under regular Working Plans. Working Plans for private forests covering an area of 79,296 acres and State *Birs* in the plains covering about 24,500 acres have to be prepared.

Name of Working Plan	Period	Area
1. Revised Working Plan of Patiala State by Rai Sahib Mian Budhi Singh, I.F.S.	(1936–37 to 1956–57)	59,817
2. Working Plan of Nalagarh State by Shri J. Singh, I.F.S.	(1934–35 to 1954–55)	25,167
3. Working Plans Kasauli Subathu and Dagshai Cantt. forests by Rai Sahib Dewan Prem Nath, I.F.S. ..	(1934–35 to 1954–55)	960
	TOTAL ..	85,884 acres

As the period of two Working Plans expires this year and of the third within a year, their revision has been taken up. In addition, Working Plans are being drawn up for all areas situated in the plains. The whole of the area will be brought under Working Plans within one year.

Extension Forestry

7. The whole of the *banjar* land in the plains of PEPSU is being reclaimed under Land Utilization and Reclamation Acts for cultivation purposes. Endeavours are being made by the Forest Department to have private inferior areas, subject to erosion, closed against grazing under Section 38 of the Patiala Forest Act, 1899, principally under the Five-Year Development Programme. An area of 735 acres in Kandaghat Sub-Division, 129·5 acres in Patiala and Kapurthala districts and 156·5 acres in Mahendragarh district, has already been closed with the consent of the owners, and the provisions of Chapter IV of the Patiala Forest Act are being applied. Sowing and planting have been taken in hand.

Strips along 273 miles of road and irrigation manors and channels are under the management of the Forest Department. Extensive measures have been adopted for raising timber and fuel wood trees, mainly *shisham*, *kikar* and *nim* along these strips and the progress is very satisfactory.

The question of taking over Railway strips is under consideration of the Government. However, 42 miles length on Dhuri–Bhatinda section has been taken over tentatively this year. Trenching and sowing have been started here.

Large scale forest nurseries are maintained in important localities all over the State for raising fuel and timber plants for planting purposes. During the rainy season plants are supplied to the villagers particularly in the Community Project areas and the National Extension Blocks for planting along approach and circular roads and along the edges of cultivated fields. 38 lac fresh trees approximately are raised annually in State Forests and on private lands.

Production data marketing arrangements

8. Timber from deodar, *chil, kail, shisham* and other miscellaneous hardwood trees, firewood and charcoal from Ban oak, *kikar,* and miscellaneous trees of the low lying hill forests and plain *Rakhs* : grass, *Bhabar* (*sabai*) bamboos, medicinal herbs and fruits of forest trees, resin from *chil* pine, gum from *jhingan* and *kikar* ; *katha* from *khair* trees and lime and building stones are the chief marketable products of PEPSU forests. The sales are made in open auctions : the purchasers marketing the products make their own arrangements. The forests are situated near cantonments, towns and habitation or along or near the motor roads and railway line ; and thus there is little difficulty in their exploitation and the disposal of the resulting produce.

The Patiala Cement Factory is producing cement from limestone obtained from 1st class *Mallah* forest of Pinjore Range (near Kalka) since 1937.

Resin extracted by contractors from *chil* forests is partially transported to Hoshiarpur and partly consumed at the local still at Taksal for distillation of turpentine oil. The annual output of resin is 19,000 maunds.

Lime and building stone, boulder shingle and sand are being extracted by purchasers through the Industries Department for which no correct data is available.

The average annual production figures of forest products are as under :—

Timber, 1,79,668 c. ft.

Firewood, 2,67,664 c. ft.

Grass and Bhabar, 1,50,000 mds.

Bamboos and Gums, 500 mds.

Resin, 19,000 mds.

Minor forest produce, value, Rs. 2,22,960.

Bhabar is primarily consumed for the manufacture of paper at Shree Gopal Paper Mills, Jagadhri, and partly for rope making. Bamboos are consumed locally and also exported to Pakistan. Plans are under consideration of the Paper Mills Management for the consumption of bamboo for paper making. Timber, firewood and charcoal and minor forest products are consumed within the State or exported to the nearby cities in the Punjab, Himachal Pradesh and Delhi States.

Forestry as an agent in soil conservation

9. Under the first Five-Year Plan, the following soil conservation schemes are in operation in the State :—

(*i*) Soil Conservation over Siwaliks.

(*ii*) Afforestation of Bhakra Dam Catchment Area.

(*iii*) Desert Control Plan.

The first two schemes are being operated upon in Kandaghat Sub-Division (Simla Hills) of Patiala District. The total catchment of the rivers Ghaggar and Sirsa aggregating to 1,76,079 acres or 275·12 square miles is included in the Siwalik Soil Conservation Scheme, while the area of catchment of Bhakra Dam in PEPSU amounts to 1,17,585 acres or 183·72 square miles. The schemes provide anti-erosion measures as trenching, check-damming, gully-plugging, afforestation and training of streams and ravines, levelling and terracing and embanking of cultivated fields, at an expenditure of Rs. 20 lacs during 5 years. The progress recorded up to the end of August, 1954, is as under :—

(*a*) Trenching	5,582 acres
(*b*) Check damming	2,147 ,,
(*c*) Afforestation	13,760 ,,
(*d*) Training of streams and ravines ..	62·3 miles
(*e*) Improvement of cultivated lands ..	988·46 acres

The work on Desert Control Plan (Mahendragarh district) has been taken in hand since April, 1953. The scheme provides the creation of shelter belt of trees along the Rajasthan border and in gaps in the Dosi hills through which sand laden winds fan out and along Dohan river, as well as fixation of sand dunes, and creation of wind breaks along the edges of cultivated fields. The estimated expenditure for five years is Rs. 8·6 lacs. The progress made last year is as under :—

(*a*) Afforestation of hills	280 acres
(*b*) Creation of shelter belts along the Dohan river ..	393 ,,
(*c*) Creation of shelter belts in gaps	730 ,,

Development Plans

10. Besides three Soil Conservation Plans mentioned in para 9 supra, the following 5-year Development Plans are in operation :—

	Area	*Cost*
	acres	Rs.
(*i*) Irrigated Plantation	4,000	5 lacs
(*ii*) Plantation of Unirrigated *Birs*	8,000	5 ,,
(*iii*) Construction of a 21-mile long road from Mallah to Joharjee to open up forests in the hilly region ..	..	5 ,,
(*iv*) Fisheries	..	2·38 ,,
TOTAL ..		17·38 lacs.

The works are in full swing and are progressing, more or less, in accordance with fixed targets.

The following achievements have been made under Plantation Plans up to the end of August, 1954.

(*a*) Trenching	.. 2,933	acres
(*b*) Planting and sowing	.. 3,847	,,
(*c*) Re-opening of trenches	.. 627·4	,,
(*d*) Weeding and cleaning	.. 248·4	,,

Wildlife

11. Prior to the formation of the Patiala and East Punjab States Union important forests in the covenanting States were treated as Game Preserves for the maintenance of the rich and varied fauna. Indiscriminate shooting was rigidly controlled under special orders by the Rulers of the States. At present Game Sanctuaries covering an area of 17,028 acres have been declared as such in different parts of the State, where shooting is strictly prohibited. The State forests are treated as game preserves under the Preservation of Fauna of Patiala Act, 1896, where shooting is permitted under special permits. General shooting permit holders are entitled to shoot in areas outside forests. The chief game found in the State includes Panther *Goral*, Barking Deer, Spotted Deer, *Sambhar*, Black Buck, Bear, Wild Boar, pheasants, partridges, *Chikor*, duck, etc.

FORESTRY IN THE PUNJAB (I)

BY ROMESH CHANDRA
Divisional Forest Officer, Simla

Summary—Organization of the Forest Department, forest types and forest resources of the State are described. Forest area and proportion to the State area is then given which is only 13.6%. Regeneration in areas closed to grazing is satisfactory and it is pointed out that efforts are being made to acquire areas for plantations. Silvicultural problems and silvicultural research are then briefly discussed. A passing reference is made to the position of Working Plans. The paper further deals briefly with extension forestry, road and canal avenues, production data, marketing and utilization problems, soil conservation, wildlife, etc.

Organization of the Forest Departmant

1. The forest administration of the Punjab State is in charge of the Chief Conservator of Forests. The State is divided into two administrative charges, known as North and South Circles, each under the control of a Conservator. The circles are divided into forest divisions or controlling charges which are tabulated below. The forest divisions are further divided into ranges or executive charges which are sub-divided into beats or protective charges.

Circle	Division
North	1. Beas
	2. Kangra
	3. Kulu
	4. Seraj.
South	1. Ambala
	2. Amritsar
	3. Gurgaon/Rohtak
	4. Hoshiarpur
	5. Karnal/Hissar
	6. Ludhiana
	7. Ropar.

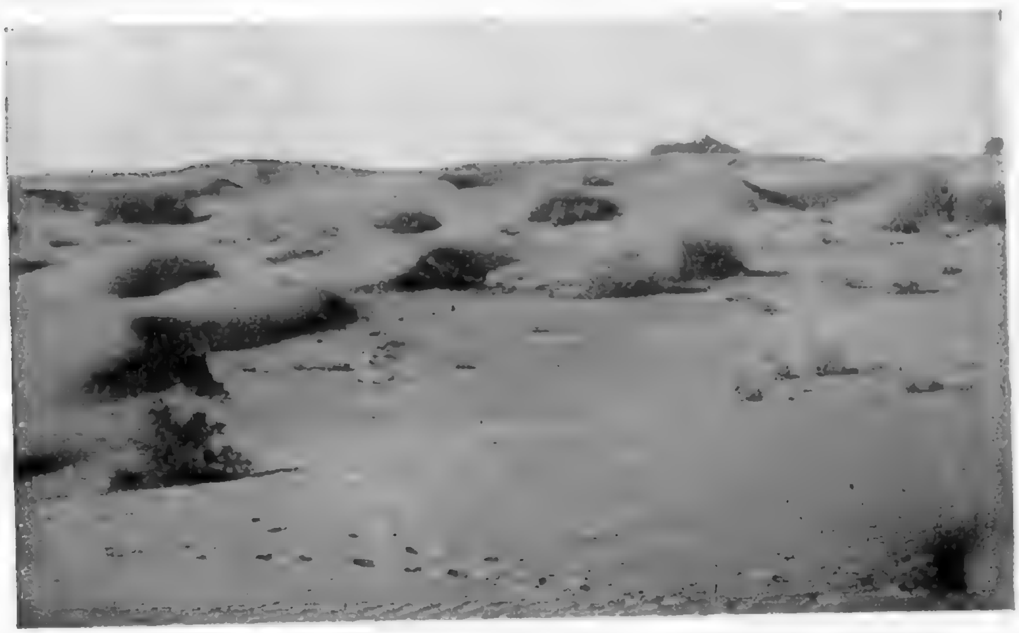
In addition to these executive charges there is a Silvicultural Research Forest Division directly under the Chief Conservator of Forests.

Brief summary of forest types and forest resources

2. According to Champion's Forest Types [Indian Forest Records (n.s.), Vol. I, No. I] the forests of Punjab fall under the following forest types :—

(1) Moist sal forest.
(2) Northern tropical dry mixed deciduous forest.
(3) Dry sal forest.
(4) Northern desert thorn forest.
(5) *Butea* forest.

No. 1. Himalayan moist temperate forests type showing the Upper oak coniferous sub-type (Fir Spruce Forest).



No. 2. Inland Dune Scrub Type.

(6) *Anogeissus pendula* forest.
(7) Inland dune scrub.
(8) Gangetic saline scrub.
(9) Dry bamboo brake.
(10) *Khair-sissoo* association.
(11) Dry deciduous scrub.
(12) Himalayan sub-tropical pine forest.
(13) Olive forests.
(14) Himalayan moist temperate forests.

(*a*) Lower oak coniferous (Ban oak and deodar).
(*b*) Middle oak coniferous (*Qercus dilatata*).
(*c*) Upper oak coniferous (*Q. semecarpifolia,* fir and spruce).

(15) Dry temperate mixed evergreen forest and dry coniferous forests.
(16) Moist temperate deciduous and dry temperate deciduous forest.
(17) Moist temperate scrub types

(*i*) Alder woods, (*ii*) Lower blue pine, (*iii*) Oak scrub, (*iv*) Secondary temperate scrub, (*v*) Thatch park land, (*vi*) Temperate bamboo brake.

(18) Alpine forest.

The chief forest resources of the State consist of timber (the bulk consists of coniferous timbers such as *Cedrus deodara* (deodar), *Pinus excelsa* (*kail*), *Pinus longifolia* (*chil*) and fir and spruce ; 3,758,000 c. ft. annually) valued at about Rs. 18,41,556, firewood valued at Rs. 2,40,369 annually, resin 99,348 maunds valued at Rs. 21,04,927, bamboos valued at Rs. 6,254, grass and fodder, medicinal plants such as *Podophyllum emodi, Gentiana kurroo, Acontium heterophyllum,* etc., *Khair* wood (*Acacia catechu*) for the manufacture of a dye known as *katha*, etc. Unfortunately the value of timber and firewood used by right holders and free grantees and the above mentioned minor forest products such as grass and fodder, *khair* wood, medicinal plants, etc., cannot be given accurately because these products are usually removed by right holders at nominal rates (known as *zamindari* rates) or free of cost. At a very moderate estimate it can be safely stated that right holders consume or remove for sale forest resources which, if assessed at market rates, may be valued at about five million rupees annually.

Area statement, giving the proportion to State area of existing forests and the proportion aimed at

3. The total area of the State and the area under different categories of forest are tabulated below :—

Total area of the State in acres according to Surveyor General of India's report	Forest area of the State in acres as given in the Annual Forest Administration report for 1952–53				
	Reserved	Protected	Unclassed	Others	Total area under
23,921,920	1,15,971	20,40,549	1,61,935	9,36,655	32,55,110

The forest area forms only 13·6% of the total area of the State. This area is too little both for satisfying the requirements of the forest products of the State as also for protecting the hill-sides and the land lying in and at the foot of these hills from erosion. According to the National Forest Policy the target is to have 60% area in the hills and 20% in the plains under forests.

The status of regeneration, natural and artificial, nature and extent of plantations

4. Regeneration both natural and artificial, is on the whole satisfactory in areas closed to grazing throughout the State. The only problem areas are the high hill forests of spruce and fir where the excessive accumulation of raw acidic humus makes it impossible for the roots of young seedlings to penetrate and gain contact with the mineral soil below. A good deal of experimental work has been carried out by the Silvicultural Research Division to tackle this problem, and it has been established that both natural and artificial regeneration can be easily obtained provided adequate measures are adopted to get rid of the layer of humus from regeneration areas. Raking of humus is of course the surest way to get rid of the raw humus, but this is too expensive. Field trials are, therefore, being carried out in Kulu and Seraj forest divisions to arrive at an economical and practicable method of getting rid of the humus. The methods being tried are : (i) the cultivation of potatoes in the regeneration areas for a few years before taking up the regeneration, (ii) introduction of buffalo grazing in order to completely disturb the accumulated humus thus creating scattered patches in the regeneration area devoid of such humus, (iii) introduction of fast-growing, broad leaved species such as poplars because it has been established that an intermediate stage of broad leaved species in the fir zone leads to a large scale reduction in the thickness of the accumulated humus and (iv) burning of the humus. This operation apparently looks very simple but in actual practice it is full of practical difficulties firstly because it is very difficult to burn the humus in the fir zone owing to its being moist, and the low temprature of the locality and secondly because fir being very fire tender there is every likelihood of destroying the mother trees by allowing a fire through the regeneration area.

Before partition the Punjab Forest Department had extensive irrigated plantations of *Dalbergia sissoo* (*shisham*) and *Morus alba* (mulberry), covering an area of 59,097 acres. These plantations are now in West Pakistan. The Punjab (I) Forest Department is now trying to bring in new areas in the plains under plantations with a view to making the State completely self sufficient as regards its firewood and other requirements.

Silvicultural problems and silvicultural research

The important silvicultural problems of the State at the moment are :—The afforestation of arid areas of the State along its south eastern border with a view to creating shelterbelts and windbreaks for checking the advance of the Rajasthan Desert in the State ; the afforestation of inundated and saline areas of the Punjab plains ; the regeneration of *chil* in the unstable zone of *chil*, i.e., between elevations of 1,500 to 2,000 feet, and the regeneration of fir and spruce forests in the high hills. Silvicultural Research division has been carrying out intensive work on 3 of these problems namely ; the afforestation of arid areas, afforestation of inundated areas and regeneration of fir and spruce forests of the high hills. A brief description of the work carried out is given below :—

Afforestation of arid areas—An experimental plot has been opened on the border of Rajasthan in village Jhunpa of district Hissar in the 1953 where various xerophytic species are being tried to find out their suitability in the sand dune zone and to find out a technique to make the selected species a success on a large scale, so that shelterbelts may be created

against the direction of the prevalent winds to check the menace of sand drift. The following species have given encouraging results. Their progress is being watched :—

Acacia senegal, *Acacia modesta*, *Prosopis spicigera*, *Zizyphus jujuba* var., *fruticosa*, *Leptadenia spartium*, *Calligonum polygonoides*, *Balanites aegyptica*, *Calotropis procera*, *Citrulus colocynthis*, *Cencrhus* spp., *Aristida* spp., *Saccharum munja* and *Cyperus arenarius*.

Afforestation of inundated areas—The inundation complicates the problem of afforestation because it makes ordinary sowing impossible due to excessive accumulation of water during the period immediately succeeding the sowings and, at the same time the inundation results in the deposition of the thick layer of stiff clay brought with water year after year which leads to acute stiffness of the soil and physiological drought during dry months of the year. An experimental station has, therefore, been opened last year in a typically inundated area of Karnal district in village Seonthi. Sowing and planting at ground level is obviously impossible ; the entire sowing and planting was, therefore, done on raised mounds. Two types of mounds were prepared viz., (i) ordinary mounds about 1½ feet high, (ii) pits 2 feet deep were dug, these were refilled with grasses and excavated earth, etc., and mounds of 1½ feet height were then made over these filled pits to allow free penetration of roots and better retention of moisture. Out of the species tried namely, *Acacia arabica*, *Butea frondosa*, *Dalbergia sissoo*, *Morus alba*, *Salix babylonica* and *Salix tetrasperma*, *Dalbergia sissoo* has given the highest success (90 per cent) on both types of mounds. *Butea frondosa*, an indigenous species of the locality, has ranked second, success being 50%. The other species failed. This is, however, the result of one year's work.

Fir and spruce regeneration—As pointed out in paragraph 4 above it has been established that fir and spruce regeneration can be easily obtained provided adequate measures are adopted to get rid of the thick layer of humus. Field trials are now under way to find out the most economical and practical method of getting rid of the humus.

Besides tackling these problems the Research Division is carrying out intensive work on nursery species, seed investigation, ecological studies, collection of statistical data, cultivation of medicinal plants, etc. There are 255 acres under nurseries which yield 2 million plants annually.

Position in regard to Working Plans, their preparation and revision

6. All the forests under the forest department are managed under regular Working Plans. The department also assists in the preparation of working plans for certain municipal forests and forests under co-operative forest societies.

Extension forestry, Avenues, Canal and Railway plantations, Farm forestry, fuel and fodder reserves

7. In order to achieve the objective of having 20% of the State area in the plains and 60% of the area in hills under forest, a good deal of propaganda is being done by the Forest Department to educate public opinion in favour of such extension. As a results thereof extensive forest areas have come under the management of co-operative societies where the people manage their forests and the Forest Department renders only technical assistance if required.

Due to shortage of compact blocks of land for allotment to Forest Department to increase the forest area, most of the roadside avenues and canal strips along the Sirhand and Western Jamuna canals have been transferred to the Forest Department for proper management. These are being stocked with suitable species such as *Dalbergia sissoo*, *Acacia arabica*, *Melia, indica*, *Melia azedarach*, *Morus alba*, *Albizzia procera*, *Terminalia arjuna*, *Eucalyptus* spp., *Prosopis juliflora*, *Millingtonia hortensis*, *Mangifera indica*, *Kigelia pinnata*, etc. The results

are extremely encouraging and at present, continuous stretches and lines of young trees cannot escape the eyes of observant travellers who pass along these roads and canals. Already an area of 5,916 acres and a running length of 41¼ miles has been successfully planted up. The strips along the Upper Bari Doab Canal have been under the management of the Forest Department since May 1945 under a regular working plan. The improvement in efficiency in the working of strips as a result of their transfer to the Forest Department can be gauged by the fact that an area of 6,037·23 acres has been planted up during the period 1945–46 to 1953–54 as compared with 988 acres planted up by the Canal Department during the period of the advisory control, 1941–42 to 1944–45. The revenue realized from the strips of this canal during the period 1945–46 to 1953–54 amounts to Rs. 27,12,130 against an expenditure of Rs. 10,27,689 thus yielding a surplus of Rs. 16,84,441.

Another act of the Government has been to transfer the entire waste land along the railway track of the Northern Railways to the control of the Forest Department in 1950–51. Regular working plan has been prepared for the railway strips and extensive planting operations are being carried out; it is expected that within the next 10 years these would be yielding handsome revenue by way of sale of forest produce.

As an additional step to add to the depleted resources of fuelwood and wood for sports goods in the State, two areas 6,605 acres and 4,264 acres were allotted to the Forest Department in 1949 at Mattewara (Ludhiana district) and Nowshera (Gurdaspur district). The former area was subsequently withdrawn. The latter, however, continues to be under the Forest Department and 600 acres are being planted up annually with *Dalbergia sissoo* in it. As the *sissoo* crop progresses, under planting of mulberry will be done, because this tree requires overhead shade in its early stages.

Most of the areas closed for regeneration yield huge stocks of grasses and fodder to meet the requirements of local residents. In addition to this most of the Co-operative Societies have a Fodder and Grass Working Circles in which improvement of the grass lands and introduction of tree species of fodder value have been successfully attempted.

8. Production data and marketing arrangements, Utilization problems

The following figures taken from the Annual Forest Administration Report of the year 1952–53 summarizes the production data of the State.

Kind of Produce		
Timber in c. ft. solid in 0/00	Firewood in c. ft. solid in 0/00	Minor Forest Produce (Resin, grasses, bamboos, etc.) value in Rs.
3,758	12,165	33,58,695

Arrangements for the marketing and utilization of forest produce are quite adequate in the Punjab plains and low hills, and full use is being made of both road and river transport, but in the high hills exploitation suffers from the chief handicap of expensive means of extraction; the problem is receiving attention.

9. Forestry as an agent in soil conservation

Punjab is perhaps the pioneer State in realizing and taking up necessary steps for the preservation and extension of forests as a soil conservation measure. The important soil conservation measures adopted are :—

(i) *Closures*—An area of 1,49,269 acres of waste lands has been closed with the voluntary consent of the people under Section 38 of Indian Forest Act and 23,16,507 acres under Sections 4, 5 and 5-A of the Punjab Land Preservation Act. In the areas so closed extensive sowing and planting operations have been carried out successfully to supplement natural regeneration.

(ii) *Cho and river training*—This operation consists in canalizing the *cho* (torrent) by vegetative spurs and lines of *Arundo donax* and *Vitex negundo* and planting of *Saccharum munja* behind the lines and when the area so planted is stabilized trees species (mostly *Dalbergia sissoo*) are put in to stock the reclaimed areas.

Levelling, terracing and wat-bundi—Levelling, terracing and *wat-bundi* of the sloping and undulating agricultural lands is one of the most important soil conservation measures. This can best be done by bull-dozers (heavy earth moving machines) and some 1,440 acres have been tackled so far by the four bull-dozers of the Forest Department. This work has been very much appreciated by cultivators and they come in large numbers to avail themselves of this facility, but the 4 bull-dozers of the Forest Department can contribute only very little to such soil conservation work, the area requiring such operation being about 400,000 acres. A scheme has now been prepared for carrying out the work at a reasonable speed with the help of a fleet of 25 bull-dozers.

As a result of the propaganda of the Forest Department considerable area of land has also been levelled and terraced by manual labour. The Department paid a subsidy to most of the people who carried out such work.

10. Wildlife

Due to its wide range of climatic (tropical to temperate) the State possesses a great variety of wildlife including Black Buck, Indian Gazelle, Ibex, Spotted Deer, Tiger, Panther, Brown Bear, quails, pea fowls, various pheasents, etc. Recently, proposals for the creation of game sanctuaries and national parks have been put forward, which are under consideration.

11. General : Vana Mohotsava

The National tree planting festival is being celebrated throughout the State and some 14 lacs of plants are planted annually. In addition to this about 4 lacs of plants are supplied, for planting, to other departments and the public at a nominal cost of 1 pice per plant.

12. Development of backward areas of Lahoul and Spiti

Greater attention is being paid to the mountain locked, dry valleys of Lahoul and Spiti situated along Tibet border. There is an acute shortage of fuelwood and timber as a result of the heavy grazing of huge flocks of sheep and goats belonging to professional graziers. For efficient management a wholetime Forest Range has been created. Since August, 1947, 16,438 acres have been demarcated and 6,390 acres, in 4 blocks, have been declared Reserved Forest under the Indian Forest Act. In order to augment the fuelwood and timber resources of the valleys, irrigated plantations of willows and poplars are being created. 5 *khuls* (irrigation channels) have been constructed and another seven are under construction.

THE FORESTS OF SAURASHTRA

BY H. R. DESAI
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Summary.—Saurashtra has 925 sq. miles, i.e., only 4.3% of its total land area under forests. Owing to past mal-treatment the forests are very open. 500 sq. miles of forest comprising most of the reserved area belong to the Tropical Dry Mixed Deciduous type, with preponderance of teak. These are worked under regular working plans. The rest belong to the 'Tropical Thorn' type. It is intended to increase the percentage of forests to 12%. The Gir forests of Saurashtra are the last home of the Asiatic Lion which is under special protection. Its present number, as per Census taken in 1950, is 227.

Physiography

Saurashtra, known as Kathiawar during the Maharatta and the British regimes, is a Peninsula on the west coast, bounded on the north by the Gulf and the Little Runn of Cutch, on the west and the south by the Arabian Sea, and on the east by the Ahmedabad district and the Gulf of Cambay. During geological times when Saurashtra was an island, the Gulf of Cambay extended into the interior and joined the Little Runn of Cutch. This arm of the of the Aribian Sea has been filled up during the course of the ages with the silt brought down by the Luni, the Banas, the Saraswati, the Sabarmati and the Mahi to mention only the chief among the many streams which have been concerned. The maximum length and breadth of the Peninsula are 220 and 165 miles respectively. The general topography is undulating, with the highlands lying diagonally across the country. The character of the orography of the tract suggests volcanic activity which began well after the commencement of the Eocene, when the Deccan lava trap came to be formed. The trap magma is generally an 'undifferentiated amygdaloidal basalt or dolerite of normal composition'. Girnar, however, provides acidic and ultra-basic variations. The denudation of the trap has given rise to the famous black cotton soil noted for its fertility.

The Gir range in the south suggests the old coastline with the sea-face in front having been filled up with the alluvium brought down by numerous streams. The highest prominence in the Girnar granite group attains a height of 3,664 feet (Gorakhnath), while Sarkala (2,110 feet) and Sasa (1,574 feet) represent the highest points in the Gir Range. The Alech (977 feet) and the Barda hills (2,091 feet) occur in the north-west. The watershed of the central highlands is mid-way between Amreli and Rajkote. The principal rivers are the Bahadar, Aji, Machhu, and the scenic Shetrunji. Most streams are dry except during the brief monsoon of about 6 weeks.

Rainfall, Climate and Soil

The rainfall is variable and is entirely dependent upon the south-west monsoon, there being no significant winter precipitation. While the Girnar hills catch as much as 55 inches of rain, the precipitation over the rest of the country averages between 20 and 25 inches. The rainfall progressively decreases from the middle-south (25–30 inches) towards the north-east and north-west (8–10 inches). The bulk of the rain falls during 5 to 6 weeks of July-August.

Artesian conditions obtain in the north-east region abutting the Little Runn of Cutch.

The climate is mild under the equable influence of the surrounding seas. There are no frosts. The sea coasts, more particularly the southern and western, are swept by strong winds often laden with salt.

The soils vary from thin laterites to rich alluvium around the sea-board. By far the most fertile soils are those derived from the lava and are known as black cotton soils. Around the Little Runn of Cutch marked salinity is discernible. Along the western and the southern coasts, where winds are high, the sea-face is covered with coarse sea-sands.

Historical Perspective

The present Saurashtra forest being only an apology for forest, its claim for a separate descriptive representation in a conspectus of Indian forestry seem hardly justified except for their hoary connection with Lord Shri Krishna, a connection which traces metaphorically the transformation of forests from 'glory to apology' not only in Saurashtra but throughout the World since the times of Krishna (the grazier) and Balarama (the cultivator).

Cities of gold said to have been built by Krishna point to the prosperity resulting from intensive land use in Saurashtra more than 5,000 years ago. The animal flocks which came along for shelter remained and multiplied when cultivation became less profitable destroying soil and soil-cover and reducing the forests to the present state of apology. They are the main problem against any scheme of reboisement of the 4,000 sq. miles of rocky waste-lands producing only a few tufts of the inedible spear-grass.

The last hundred years of the awakening about forest importance and proper land use everywhere else in India have seen very little of such activities in any of the numerous feudal administrators of Saurashtra. Thus the hilly areas of Gir, Girnar and Barda are the only forests left in Saurashtra.

Organization of the Forest Department

Only Junagadh State had employed qualified forest officers for the last 40 years with intervening breaks. After the merger of all the States, the Saurashtra Government borrowed the services of a trained and experienced officer from Punjab who tried his best to put the confusion into order. *Qualified Divisional Forest Officers, Range Forest Officers and Foresters* were obtained on loan and new schemes for forest-extension and training of staff were formed. As per the final set-up organized by him there are six divisions twelve ranges and sixty rounds. The units are kept small in view of forest-extension work spread throughout the five districts of Saurashtra. A Conservator of Forests from Bombay State obtained on loan is now at the head of the Forest Department with headquarters at Junagadh. Five officers are already trained and more are being trained to meet future requirements.

Forest Types, Condition of the Forests and Resources

About 450 sq. miles out of the total area of 925 sq. miles are of the Tropical Dry Mixed Deciduous type in which teak forms about 50 to 60% of the crop. Some nearly pure pole crops of teak are also met with on the lower Girnar hills. The rest are Tropical Thorn forests formed mainly of *Acacias with scattered growth of other thorny and dry species. The Bamboo Dendrocalamus strictus* is found in most places. Though growing to smaller dimensions it yields comparatively solid culms which are much in demand everywhere. The Gir and Girnar forests formerly belonging to Junagadh State were supposed to be worked under written working plans but in actual practice the prescriptions remained only on paper. 'Coppice with Standards' 'Coppice with Reserves' complete protection 'Selection' and 'Clear-felling' have been all applied for varying periods as per recommendations of different officers. Owing

to the faulty marking and bad working the resulting crop consists of malformed crooked stuff in remote areas and repeatedly exploited young coppice on high stumps in accessible areas. Locally heavy grazing around established cattle camps and unrestricted removal of dead-wood on head loads have created numerous blanks. A few coupes worked under proper supervision contain good crops of young poles. The locality factors indicate a 30 to 40 feet crop height and 20 to 30 inches breast height girth for teak.

The Barda hills in the S.W. comprising about 100 square miles were under two jurisdictions, viz., Porbandar in the South and Jamnagar in the North. The localized heavy grazing of permanently settled graziers has reduced more than 70% of this area into very open thorny scrub containing stunted, patchy stands of *Acacia senegal* and *Acacia arabica*. The rest of the Barda forests which were constituted as reserves by the Porbandar Government contain a higher proportion of miscellaneous species and are not so open. About 300 square miles of discontinuous pieces of waste land which are yet not demarcated extend northwards from the Barda hills and contain open stands of thorny scrub. In addition scattered waste-lands from 5 to 5,000 acres in extent exist throughout Saurashtra which may aggregate to about 3,500 square miles. They are in charge of the Revenue Department at present but after distributing about half of them for permanent settlement of nomad graziers the rest will be available for forest extension schemes or village forests.

The different categories of forest areas in charge of the Forest Department at present are tabulated as below :—

Total Area of the State	Forest Area in Square Miles						
	Reserved Forest	Protected Forest	Municipal Forest	Private Forest	Unclassed Forest	Total forest area	Proportion of forest to the area of the State
1	2	3	4	5	6	7	8
21·500	583	nil	nil	not available	372	925	4·3%

The State Government are alive to this deficiency of forest and intend to increase it to 12% in 30 years. The forests yield small-timber, firewood, bamboos, grass, honey, wax, gums, and leaves for country cigarettes. The State has to import large quantities of timber and charcoal from the neighbouring areas of Bombay State. The average out-turn of forest produce is as under :—

	Quantity	Revenue Rs.
Small timber	2,50,000 c. ft.	3,50,000
Firewood	15,00,000 c. ft.	
Charcoal	1,50,000 Bengal maunds	
Bamboos	..	50,000
Other minor forest produce and miscellaneous items	..	1,00,000






Top—*Left*—Young pole crop in lower valleys in Gir. *Right*—A view of Girnar lower slope Forests.
Centre—*Left*—Badly worked distant areas. *Middle*—Bane of the Forests - Buffaloes delight.
Right—Open scrub.
Bottom—A view of Gir Forests.

Coupes are sold standing to coupe contractors. The minor forest produce is also farmed out to contractors. Revenue from head-loads of dead firewood and some minor produce and minor minerals is realized on permits.

Regeneration and Plantations

Natural regeneration of teak and other timber species does take place to some extent in good soils, favourable sites and aspects. The tops, steeper hill-sides and heavily grazed flats are barren. Coppice regeneration is fully successful for teak and satisfactory for other species. In annual coupes artificial regeneration is done on burnt rabs and along contour trenches in existing blanks to supplement the natural and coppice regeneration. Plantation activity has been further extended under the five-year plan and there is a special scheme to renovate Gir forests. About 1,000 acres have been taken up annually for such concentrated work both in the felled area and other blanks by direct sowing, transplanting and stump-planting.

Silvicultural Problems and Research

The main problems are to raise coastal plantations of *Casuarina*, shelter belts along desert border and to fill up denuded blanks and waste lands with hardy, quick growing trees as economically as possible. The improvement of grazing and fodder is the most difficult problem requiring conscientious co-operation of the non-responsive public. No silvicultural research was done in the past. The coastal plantations have received a serious set-back from the salt laden sea-water spray specially during the high winds from April to July on the South and South-West coast. Even *Prosopis juliflora* is affected and top shoots are dry. A cheap shelter guard of brushwood for each plant seems to be the only solution at present. An alternative method is to start planting after the middle of August. A trial and error search to find a tree or shrub species immune to this salt-spray has not yet been successful.

Working Plans

Working plans for the main exploitable forests of Gir and Girnar have been completed and sanctioned. For the rest of the forests not intended to be under regular exploitation only short-term plantation schemes are prepared and adopted. The systems of working adopted for the Gir and Girnar forests are modified Clear-felling and complete regeneration of the most accessible areas, complete protection of all the areas above an altitude of 1,500 feet, Coppice with Reserves of miscellaneous shade and fruit species on the lower slopes, and selection of undesirable stems on the higher slopes below the Protection working circle limits.

Extention Forestry and other Plantations

It is intended to plant up about 1,800 square miles during the next 30 years. This work will be mainly on catchment areas, other waste lands, open forest areas the coastal sand-belts on the desert borders. In addition 14,000 acres of village plantations, 170 miles of railway and road-side plantations are proposed to be tackled during the period of the next Five-YearPlan. During the current year 500 acres of desert-belt and 1,000 acres of inland plantations in waste-lands and denuded forest areas, and 1,000 acres of costal plantations are taken up.

Market and Utilization

Saurashtra has a good mileage of distributed meter-gauge rail lines. So the lead from any part of the forests to rail-heads is not excessive. Nearly all firewood is extracted. There are sufficient fair weather roads but their maintenance becomes coastly and difficult as the

terrain is very hilly. It is intended to transform about 100 miles of main forest roads into all weather metalled roads. All forest produce is consumed locally and has a ready market. Except a few small scale saw-mills, and toy and furniture making on an individual, cottage industry scale, there are no other wood working industries.

Forests in soil conservation

Saurashtra has not got very large rivers, yet nearly all the main rivers are being bunded for small irrigation schemes. It is indended to plant up all unoccupied lands in the catchment areas of these rivers. Creation of live hedges round all individual fields as a measure against erosion is also being strongly encouraged.

Wildlife

The rulers and chieftains, though fond of *shikar* themselves were very jealous about anybody else shooting even a sparrow. They had means to exercise good protection which resulted in fair survival or even increase of wildlife. It is said that during the interval before special measures for wildlife protection were passed by the present Government destruction by poaching and for crop protection went on merrily.

Deer, *sambhar* and *chital* have become scarce but pigs, *nilgai* and panther still abound. Tiger has gone away from Saurashtra since long leaving the field clear for the lion. Lions existed in all the hilly portions of Saurashtra. Now they are confined only to the Gir forest area of about 600 square miles. This is also the only and the last home of the Asiatic Lion. It was on the verge of extinction 25 years ago when its numbers had gone down to less than 15. Since then the Junagadh State took strict measures for its preservation and so now their strength is estimated to be a little over 200. It appears as if these 600 square miles are not adequate for them as they are always found wandering out of it and lifting cattle from villages which are situated as much as 20 miles away from the forest boundary.

FORESTS AND FORESTRY IN UTTAR PRADESH

BY S. K. SETH
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Summary.—The past history of U.P. forests and the present organization of the Forest Department are briefly touched upon. An account of the principal forest types with special reference to sal forests, follows. Next, forest resources, classification of forest areas, silvicultural systems and the status of natural and artificial regeneration, are reviewed. Short sections are devoted to silvicultural research and Working Plans. Extension forestry and forestry in soil conservation are briefly described with details of localities, areas, species, etc. The account is closed with short note on wildlife, five-year plans, nurseries and seeds, fruit trees, grazing, communications and financial results.

Historical perspective

The U.P. sal forests were considered almost inexhaustible even 150 years ago and as early as 1,825 Dr. Wallich had reported on the ruthless manner in which they were being exploited. Forest Conservancy was, however, started only in 1850 and a Superintendent was appointed in 1854, "the result of whose bad management was the completion of the ruin of almost all the forests that still contained good-sized" trees. The rapid construction of Indian railways after 1857 also contributed to the huge destruction of the forests. Commissioners of divisions were appointed *ex officio* Conservators in 1860 and continued to excercise this function till 1868. In 1862 when Dr. Brandis was asked to advise on the introduction of a general policy for the administration of forests, he proposed the appointment of Forest surveyors to prepare detailed maps in the first instance. Webber was one of the appointments and he was the first to explore the unworked hill forests of Kumaon and Garhwal. The Avadh forests were demarcated in 1861 and 1862 and Dr. Brandis carried out a valuation survey in 1863. Finally a forest department with its own Conservators was inaugurated in 1868 and regular management was initiated. Prohibition against grazing was introduced progressively from 1867 and fire protection over the whole forest estate was accomplished in the early seventies.

Organization

The State forests are under the overall control of a Chief Conservator of Forests. They are divided into five territorial circles and 33 territorial divisions. In addition there is a Working Plans and Research Circle comprising of 5 Working Plans and one research division. There is also a Foresters' Training division and a Utilization-cum-Fuel and Transport division. The Circles consist of 4 to 10 divisions and are under the charge of Conservators. The division, under the charge of a D.F.O., is an administrative unit varying from about 140 to 850 sq. miles in area and may be part of a Civil district or spread over a number of districts, depending upon the concentration of forest areas. The division usually consists of five to ten ranges, each under a Range Officer, divided into about the same number of beats, under the charge of forest guards. The administration is assisted by a number of Asst. Conservators of Forests, Deputy Rangers and Foresters who do not hold territorial charges.

The present staff consists of 90 superior officers assisted by 171 rangers, 189 deputy rangers and 465 foresters. In addition, there are 1,351 forest guards, 205 cultural and plantation *jamadars*, and 786 other hands excluding permanent labour. The strength of the clerical staff is 638 and there are 1,811 inferior subordinates like orderlies, *chowkidars*, etc. All the superior officers and about 600 of the subordinate staff are trained foresters. Some forest guards have also received a short training.

Forest types

The present extent of State forests is 13,375 sq. miles. The forest estate comprised only 6,207 sq. miles in 1947 and the increase in area during the last seven years is largely due to the integration of the former States of Tehri Garhwal, Banaras and Rampur and the enclaves, as well as due to vesting in the Government of private forests and wastelands as a consequence of land reform legislation. Most of the newly vested areas are as yet imperfectly organized and the major portion of revenue accrues from the old reserved and protected forests.

The forests of U.P. are spread over a wide range of climatic regions and include such diverse types as alpine grasslands and desert vegetation. According to Champion's classification the following types are represented :—

Climatic climax types	19
Edaphic types	12
Primary seral types	8
Secondary seral types	8

The most valuable species occur gregariously over extensive areas in almost pure crops; *Shorea robusta* (sal) *Pinus roxburghii* *(*chir*) and *Cedrus deodara* (deodar) being the most noteworthy.

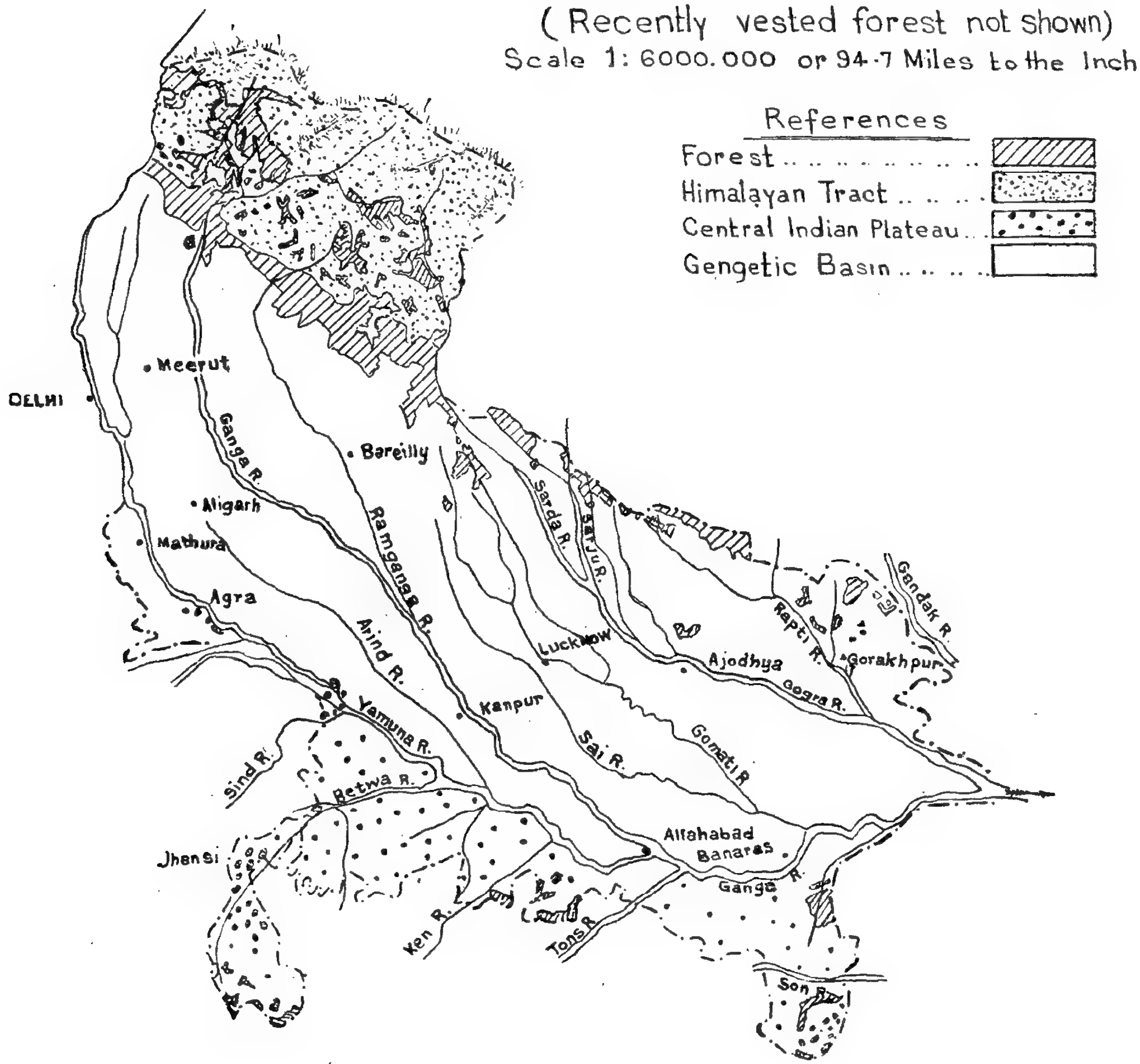
The sal forests occupy an area of about 2,727 sq. miles. They are divisible into two main sections – the dry sal and the moist sal. The dry sal occurs partly in the Siwalik hills and partly in the Gangetic plains.

The moist sal forests are broadly divisible into the hill forests, the high level alluvial and the low level alluvial types. The chief characteristics of the sal forests are summarized in the following table :—

Type	Distribution	Typical quality	Chief rock and soil	Outstanding features
4b.$C_{\cdot 2}$ A^1 Dry Siwalik sal	Outer Siwalik hills	III–IV	Siwalik sand rock and conglomerates	*Eulailopsis binata* grass
4b.C_2.A_2 Dry Gangetic sal	Saharanpur, Ramnagar, Bahraich	III	Sandy alluvium	Drought mortality
3b.C_1.B^1 moist (Siwalik) western hill sal	Siwalik hills	II–III	Nahan sandstone with light soil	..
3b.C_1.B_3. moist high level alluvial sal	North-western *bhabar* terraces and gravels ; Dehra Dun to North Kheri	II	Alluvial loamy soils, locally gravelly	Dense *Mallotus* and *Clerodendron*
3b.C_1.B_4 moist low level alluvial sal	Central *tarai* ; South Kheri, Pilibhit	III	Sandy alluvium	Heavy grass, dry sub-soil
3b.C_1.B_4 (APP) Frosty sal *chandars*	South Kheri, Pilibhit	III–IV	Alluvial, dry sandy sub-soil	Heavy grass with frosted regeneration

* New name for *Pinus longifolia* (Hon. Ed.).

RESERVED & PROTECTED FORESTS
OF UTTAR PRADESH
(Recently vested forest not shown)
Scale 1: 6000.000 or 94·7 Miles to the Inch.



Type	Distribution	Typical quality	Chief rock and soil	Outstanding features
$3b.C_1.B_5$ a Moist low level old alluvium sal	Eastern *tarai* Gorakhpur, Gonda	III–IV	Yellow clayey alluvium	Low undergrowth of shrubs, not grass
$3b.C_1.B_6$ West *tarai* sal	Tarai and Bhabar Estates	III–IV	Grey clayey alluvium	Wet sub-soil *Calamus*

The *chir* forests occur in the outer himalays between 3,000 to 6,000 feet on a variety of rocks and soils and occupy an area of over 1,200 sq. miles. The forests are almost pure with few associates in the top canopy. In the lower canopies *Quercus incana* and *Rhododendron arboreum* are the main species. *Arundinella nepalensis* and *Heteropogon contortus* are the characteristic grasses.

The deodar forests are much less extensive and pure in comparison. They occupy a gross area of less than 100 sq. miles in the altitudinal range of 5,500 to 10,000 feet. They are always associated and more or less mixed with the Himalayan spruce and fir, *Picea smithiana* and *Abies pindrow*, the western oaks – *Quercus incana*, *Quercus floribunda* and *Quercus semecarpifolia*. The spruce, fir and *Q. semecarpifolia* mixtures occur in the higher zones.

Forests of *Abies pindrow*, *Picea smithiana*, the Himalayan oaks, Dry teak in the Vindhyan regions, riverain *Acacia arabica*, *Acacia catechu*, *Dalbergia sissoo*, alpine birch and *Rhododendron*, *Dendrocalamus strictus* bamboo in the dry deciduous belt and edaphic pockets of *Terminalia tomentosa*, *Butea monosperma*, *Anogeissus pendula* and *Boswellia serrata*, Cypress on limestone outcrops, are other important associations which are met with more or less pure. Mixed deciduous forests in the tropical, sub-tropical and temperate zones, comprising climax, edaphic and seral types account for the rest of the forest area.

Resources

An idea of the forest resources of the State will be obtained from the subjoined table :—

Species		Area sq. miles	Average annual timber yield ; 000 c. ft. in round
Pinus roxburghii	..	..	5,500
Cedrus deodara	..	..	400
Other coniferous	..	..	800
Total coniferous	..	1,756	6,700
Shorea robusta	..	2,727	8,000
Terminalia tomentosa	..	..	500
Dalbergia sissoo	..	..	150
Salmalia malabarica	..	..	300
Other broad leaved	..	..	500
Total broad leaved	..	11,619	9,450
GRAND TOTAL	..	13,375	16,150

Exploitation is carried out by purchasers agency. Standing trees are sold by open auction and trees are felled and converted, and products exported and marketed by the contractors. The department maintains adequate supervision to ensure proper working.

Classification of forest area :—

Total area of State	1,13,409 sq. miles
Total forest area	16,534 ,,
Total State forest area	15,295 ,,

Total area under Forest Department :—

Reserved forests	8,155 sq. miles	13,375 sq. miles
Protected forests	1,079 ,,	
Unclassed forests	4,141 ,,	

Classification of forest area (sq. miles)

Class	State		Communal	Private	Total	% of total State area
	Reserved and protected	Unclassed				
Exploitable						
(*i*) Conifers ..	1,787	....	3	2	1,792	1·58
(*ii*) Broad leaved ..	4,737	607	8	474	5,826	5·14
Potentially exploitable						
(*i*) Conifers ..	380	..	2	..	382	0·34
(*ii*) Broad leaved ..	3,134	3,257	7	677	7,075	6·24
Other land classed as Forest	1,116	277	..	66	1,459	1·29
TOTAL	11,154	4,141	20	1219	16,534	14·58

Silviculture and management

The classification of areas under the forest department on the basis of Silvicultural systems and regeneration operations is given below :—

Silvicultural system	Area sq. miles
Selection and Uniform	5,745
Clear-felling and artificial regeneration ..	306
Coppice with Standards	496
Simple Coppice	286
Afforestation	206
Not under Silvicultural systems (Protection, grazing, etc.)	6,336
TOTAL ..	13,375

Areas under concentrated regeneration 1953–54 (sq. miles)

Class of forest	Area under concentrated natural regn.	Area regenerated mainly by coppice	Area artificially regenerated		Total cost in Rs.
			In existing forest	Afforestation	
Conifers	485	..	..	..	1,62,000
Broad leaved ..	76·6	34·6	7·8	8·6	19,84,000
TOTAL ..	561·6	34·6	7·8	8·6	21,46,000

Natural regeneration by seed : Natural regeneration is being chiefly relied upon in case of sal, and the coniferous forests. The major portion of sal forests, especially those in the hills, is being managed under the Selection System. A much smaller area comprising the best alluvial sal forest is under some form of shelterwood system. The application of the Uniform System with a regeneration period of 30–40 years has not generally proved satisfactory and the present tendency is to retain only those areas under shelterwood systems which appear to be best suited for this type of management, to increase the regeneration period to 60–90 years under a form of the Irregular Shelterwood system and to regenerate past failures by artificial means. *Chir* is being successfully managed under the Uniform System.

Natural regeneration by coppice is practised over relatively small areas, particularly in the miscellaneous forests of the southern zone.

Clear-felling followed by artificial regeneration is practised in case of sal in Gorakhpur division and for regenerating mixed deciduous forests. The method adopted is either *taungya*, exclusively so in case of sal, or departmental plantation.

Plantations

Apart from the *taungya* and other plantations referred to above, the plantation effort is largely confined to afforestation of grasslands and wastelands which contain little tree growth of any value, or badly degraded forest areas which were overexploited in the past under private ownership and are now in urgent need of rehabilitation. Plantations are also created in order to check erosion and arrest the spread of arid and desert conditions.

The pace of plantation and afforestation has been greatly accelerated in the last few years. The total area of plantations undertaken in different years, including plantations under extension forestry and soil conservation schemes, is given below :

Year	*Acres*
1947	2,734
1948	3,698
1949	4,034
1950	5,093
1951	6,317
1952	8,871
1953	11,570
1954	17,572

Plantations undertaken in 1953 in reserved and protected forests, in order to regenerate clear-felled areas, to replace comparatively worthless forest by more valuable species, to fill up grassy blanks, etc., amounted to 559·5 acres in existing forest and 1,689 acres under afforestation projects.

The chief species sown or planted were :

Hills : *Juglans regia, Fraxinus micrantha, Pinus roxburghii, Pinus wallichiana, Cedrus deodara.*

Plains : *Shorea robusta, Salmalia malabarica, Dalbergia sissoo, Acacia catechu, Acacia arabica, Morus alba, Tectona grandis, Cedrela toona, Ailanthus excelsa, Syzygium cumini, Holoptelea integrifolia, Trewia nudiflora, Adina cordifolia, Hymenodictyon excelsum, Albizzia* spp., *Terminalia tomentosa, Terminalia arjuna, Kydia calycina, Mangifera indica, Prosopis juliflora, Dendrocalamus strictus.*

Silvicultural problems and Silvicultural research

The silvicultural problem of paramount importance confronting the State is how to achieve natural regeneration of the valuable submontane sal forests and the major part of the research effort is concentrated on this problem. The question was studied in great detail by a Sal Symposium organized to tour the problem areas in U.P., M.P. and Bihar in 1953, and as a result of its recommendations a fresh series of experiments is being laid down. At the same time it has been recognized that these sal forests are better suited to management under a group or Irregular shelterwood system with a long regeneration period amounting to about one-half to two-thirds of the average rotation and prescriptions in conformity with these principles are being incorporated in the Working Plans. Meanwhile, as long as uncertainty persists with regard to the proper Silvicultural measures to adopt, only the most suitable areas with existing advance growth are being taken up for regeneration under a shelterwood and the past failures in *Quartier bleu* are proposed to be restocked by artificial methods.

Research on *usar* and ravine grasslands, bamboos, afforestation of wastelands, irrigated mulberry plantations, resin tapping, nursery experiments on the best methods for artificial propagation of various species of industrial importance, introduction of hybrid poplars, willows and *tung*, experimental cultivation of lac, etc., is also continuing.

Working Plans

The position with regard to Working Plans is satisfactory so far as old reserved and protected forests are concerned. However, since the area under the forest department has been almost doubled during the past few years, there is a large area which has to be brought under proper management and this is now receiving the attention of the Department. The position regarding preparation and revision of Working Plans during 1953–54 is summarized in the following table :—

Areas under sanctioned Working Plans (sq. mls.)	% of total forest area	Areas not under Working Plans (Square miles)		
		Plans under preparation	Plans not under preparation	
			Required at present	Not required at present
9,191	69	115	3,929	137

Revisions (Square Miles)			Total expenditure
Due or required	In progress	Revised plans sanctioned during the year	
512	1,477	685	Rs. 1,89,383

Most of the valuable forests are enumerated totally or partially during Working Plan revisions. Reliable estimates of the growing stock are available for 3,046·4 square miles of valuable forests and the yields for *Shorea robusta*, *Cedrus deodara*, *Pinus roxburghii*, *Picea smithiana* and *Abies pindrow*, *Acacia catechu*, *Salmalia malabarica* and a few other species are based on such estimates.

Extension Forestry

Extension forestry is actively engaging the attention of the forest department as will appear from the following abstract of areas of various classes which have been afforested from 1948–49 to 1953–54:

Canal bank plantations	..	571·5 miles
Road-side avenues	..	568·4 ,,
Railway land	..	555·5 acres
Old camping grounds	..	155 ,,
Other Government land	..	20 ,,
Farm forestry (village lands)	..	1,023 ,,
Fuel and fodder reserves	..	5,098 ,,
Colonization areas and State farms	..	5,390 ,,
Demonstration areas	..	24 ,,

In the canal bank plantations *Dalbergia sissoo* is the principal timber tree and *Acacia arabica* the principal fuel species. Along road-sides, avenue species suitable to the locality are planted, the most important being *Dalbergia sissoo, Mangifera indica, Syzygium cumini, Ailanthus excelsa, Terminalia arjuna, Terminalia belerica, Madhuca indica, Tamarindus indica, Pongamia pinnata, Albizzia procera, Albizzia lebbeck, Azadirachta indica* and *Cedrela toona*. Ornamental flowering and foliage species like *Delonix regia, Cassia fistula, Bauhinia variegata, Polyalthia longifolia*, etc., are also introduced near towns and cities.

In village plantations the emphasis is on raising *Dalbergia sissoo* and *Acacia arabica* in suitable sites but a mixture of *Acacia catechu, Albizzia* spp., *Madhuca indica, Adina cordifolia, Cedrela toona, Terminalia arjuna, Salmalia malabarica*, etc., is also being introduced.

Forestry as an Agent in Soil Conservation

For the present active soil conservation measures are confined to the south, south-west and west of the State in the region of Yamuna–Chambal ravines, the Rajasthan desert border and the highbanks and inundated flats of the Ganga. Recently the Gomati–Tapti catchment afforestation scheme has also been initiated :

The Rajasthan border afforestation scheme was initiated in 1953 and comprises of the following :

(a) Forest belt and sandy wastes in Agra and Mathura districts.

(b) Erosion control in Giri–Govardhan tract in Mathura district.

(c) Reclamation of Yamuna and Chambal ravines in Agra, Mathura and Etawah districts.

(a) This consists of afforesting compact blocks of land wherever available in order to create a sort of windbreak along the Western border of Agra and Mathura districts, supplemented by shade lines along all metalled roads running North to South in the districts. In due course similar rows of trees will also be planted along canals and railway lines running North to South. 1,093 acres of forest blocks and wastelands were planted up during 1953. 16 miles of roadside avenues were also planted.

(b) The afforestation work was started in 1951 and 331 acres were afforested up to the end of 1953. 20 acres were specially devoted to planting ornamental trees during the 1953 *Vana Mahotsava*. The '*parikrama*' path of 14 miles has been planted with shade trees and avenue planting was also done on an additional 3 miles.

(c) In addition to areas mentioned under (a), 1,032 acres were taken up in the Etawah district.

In the forest blocks and ravine lands the usual method consists in sowing or planting drought resistant species like *Acacia arabica*, *Acacia leucophloea*, *Prosopis juliflora* and *Prosopis spicigera*, *Ailanthus excelsa*, *Holoptelea integrifolia*, *Dalbergia sissoo*, *Terminalia belerica*, *Pongamia pinnata*, *Azadirachta indica*, *Bauhinia variegata*, *Cassia fistula*, and a few others in a system of ditch-ridges prepared along the contours. Bunding and gully-plugging is done wherever feasible to conserve moisture and check erosion, and a series of drains is also sometimes excavated at the heads of active gullies and ravines.

In the colonization area near Hastinapur on the Ganga, a total of about 4,825 acres has been afforested. About 1,325 acres are devoted to matchwood plantations of *Salmalia malabarica*, *Ailanthus excelsa* and *Kydia calycina* mixed with a sprinkling of other species, and 3,500 acres are under miscellaneous species chiefly *Dalbergia sissoo*, *Acacia arabica*, *Acacia catechu*, *Albizzia* spp. and *Morus alba*. About seven miles of roadside avenues have also been planted.

Wildlife

The State is fairly rich in wildlife of all kinds . Among the carnivora the tiger, the panther, and the snowleopard are noteworthy. The Himalayan black-bear and the sloth-bear also occur widely. *Sambhar*, *chital*, barking-deer, musk-deer, hog-deer and *barasingha* among the deer family ; *chinkara*, black-buck, *nilgai* among the antelopes, and mountain goats and sheep are important game animals, in addition to crocodiles, pythons, hyaenas, wild dogs, etc. Herds of elephants roam the T and B, Haldwani, Ramnagar, Kalagarh, Lansdowne, Dehra Dun and Saharanpur forests. Important avi-fauna includes wild-fowl, pea-fowl, partridges, pheasants, woodcock, florican, wild duck and geese. The mountain lakes and streams are fairly well stocked with game fish notably the *mahseer*. Trout have also been introduced in a few localities of which the Gohna lake in Garhwal is the most famous.

About 90 tigers and 40 panthers are shot annually. The bag of *chital* and *sambhar* exceeds 60 and 180 respectively.

The well-known Hailey National Park is situated in the Ramnagar and Kalagarh divisions and occupies an area of about 80,000 acres in the Siwalik hills. In addition, there are

two game sanctuaries. – The Rajaji sanctuary (about 65,000 acres) in the Saharanpur Siwaliks and the Kansrau sanctuary (about 19,000 acres) in the Dehra Dun division. Another important refuge for wildlife is the Nanda Devi sanctuary enclosing the approaches to the sacred peak. In order to afford protection to migratory birds especially wild duck and geese, a large natural *jheel*, the Singhrahna in the northern forests of the Gorakhpur division, has been declared a bird sancturay.

Five-Year Plans

The Chief feature of the five-year plans is the creation of additional plantations and improvement in communications. During the current plan 2,500 acres per annum of miscellaneous species, 500 acres per annum of mulberry and 250 acres of ash, maple, walnut, etc., are being raised. 4,000 acres of fuel and fodder reserves in ravine and arid areas and 1,000 acres of afforestation in the catchment areas of the Gomati and Tapti rivers are scheduled for 1954–55 to 1955–56. In the second 5-year plan starting in 1956–57, 23,000 acres of miscellaneous plantations, 5,000 acres of fuel and fodder reserves and 5,000 acres of river catchment afforestation have been provided for annually. The development of 6,00,000 acres of class I forests has also been included in the plan.

Nurseries and seeds

In order to ensure success of the large scale plantations programme a large number of nurseries is being maintained and the number will increase considerably when the much larger areas envisaged under the second 5-year plan are taken up. On 1st January 1954 there were 305 nurseries in the State, occupying an aggregate area of 443 acres and containing about 47,00,000 plants.

About a thousand maunds of seeds of various species were collected and utilized in the various nurseries and plantations in the 1954 rains.

Fruit trees

Propagation of fruit trees of various species in the regular plantations and in the avenues is being encouraged. In 1952–53 about 55,000 fruit trees were planted throughout the State.

Grazing

The forests provide cheap grazing to a substantial proportion of the State's livestock. The number of animals grazed in U.P. forests during 1952–53 is given below. The amount of grazing fees actually realized was Rs. 2,52,180 as compared with Rs. 11,94,254 forgone during the year.

Animals	At full rates	At privileged rates	Free by right-holders	Free during pleasure of Government	Total number grazed
Buffaloes ..	97,921	9,606	82,107	79,644	2,69,278
Cows ..	3,17,009	62,258	7,44,112	2,76,195	13,99,574
Goats & sheep	91,171	22,616	1,38,046	96,267	3,48,100
Other animals	4,460	1,198	2,638	390	8,686
TOTAL ..	5,10,561	95,678	9,66,903	4,52,496	20,25,638

Communications

The forest department maintains about 5,412 miles of motor and cart-roads and 4,262 miles of bridle and other paths in the forests for inspection and export. There are two tramways, each with a permanent track of about 14 miles, for the extraction of forest produce in Gorakhpur and Haldwani divisions. While the Haldwani tramway has temporarily stopped working due to competition by road transport, the Gorakhpur tramway exported 2,50,971 cubic feet of timber, 14,775 cubic feet of round timber, 99,950 cubic feet of off-cuts and 3,89,800 cubic feet of fuel during 1953–54.

Financial results

An abstract of the Revenue, Expenditure and Surplus for 1953–54 will give an idea of the financial implications of forestry in the State.

		Rs.
Revenue :		
	Government agency	35,05,237
	Purchaser's agency	3,16,79,227
	Others	12,66,997
	TOTAL ..	3,64,51,461
Expenditure :		
	Conservancy, maintenance and regeneration ..	80,23,878
	Establishment	63,32,770
	Transactions	28,435
	TOTAL ..	1,43,85,083
Surplus :		
	Nett surplus	2,20,66,378
	Nett revenue per square mile of forest ..	2,725
	Nett surplus per square mile of forest ..	1,649

FORESTS OF VINDHYA PRADESH

BY D. D. SAIGAL, I.F.S.
Chief Conservator of Forests, Rewa

Summary—The forests of Vindhya Pradesh are rich in all varieties of forest produce and are a big asset to the State. They provide 33% of the gross revenue. Most of the present revenue is from minor forest products. They are, however, capable of great development. A start has been made in the first five-year plan. Most of the development is expected in the second five-year plan when it is hoped to bring all areas under systematic management. Development of forest industries is an item of great importance. The forests also abound in wild game which provides a great attraction to the sportsmen.

Introduction

Situated as they are in the centre of the Indian Union the forests of Vindhya Pradesh escaped the destruction that took place during the troublous periods of the history of India. The region, especially the eastern portion (Baghelkhand) was untouched by the invading armies as it was well away from the main Deccan route in the west and the Bengal route in the north. The western portion (Bundhelkhand) however, did not escape the notice of the invaders with the result that large stretches of the country are bare of any tree growth and the populace has to travel long distances to meet their essential requirements from the forests. The forests occur both on the hills and in the plateau and present some of the finest scenery in India. The forests are also famous for their mention in the Ramayana as Lord Rama spent 12 of the 14 years of his exile in their midst. The orthodox amongst the populace believe that their present condition is due to Divine Blessings. Be that as it may in its forests Vindhya Pradesh has an asset of incalculable value.

Distribution, Area and Forest Types

Out of a total land area of 23,186 square miles the forests occur on 7,714 square miles i.e., 33·27%. The distribution is adequate except in the western districts of Tikamgarh and Datia. In these two districts the percentage works out to between 10 and 15.

The forests can be divided into the following types :—

1. Pure teak forests.
2. Pure sal forests.
3. Mixed forests containing various miscellaneous species ; mainly *Anogeissus latifolia*, *Boswellia serrata*, *Terminalia arjuna*, *Zizyphus xylopyra*, *Butea frondosa*, *Bassia latifolia* and various other species.
4. *Khair* (*Acacia catechu*) forests.
5. Bamboo forests.

Mixtures of the above types are fairly common. Teak attains its best quality when growing in mixture with miscellaneous species. Sal is generally associated with bamboos.

Forest Produce

Vindhya Pradesh is unique amongst the States in India in that it receives more cash returns from the minor forest products than from timber and firewood. The reason is not far

to seek. Means of communication are few and large areas, especially of sal, are unworked for this reason. The chief minor products of the forests are :—

1. Lac.
2. *Bidi* (*Diospyrus melanoxylon*) leaves.
3. *Katha* (from *Acacia catechu*).
4. Myrobalans (*Terminalia chebula*).
5. Bamboos.
6. *Bagai* grass, Kulu (*Sterculia alata*) gum, medicinal herbs, *Siharu* (*Nyctanthes arbor-tristis*) Custard apple and *Chiranji.*

Forest Management

Forest management in the way of regular working plans is absent. The erstwhile States of which the Vindhya Pradesh is composed were content with annual plans of operation which gave them the maximum financial return. Most of the forests were consequently subjected to heavy fellings especially in the late forties, when the States were liquidated and consolidated into the State of Vindhya Pradesh. But such is the recuperative power of the soil that the forests have re-appeared and the regions which had been completely bared are again green. The immature crops therefore predominate, mature crops existing only in the remote areas of Baghelkhand where means of communications are few and far between. The future management of forests therefore presents an interesting problem. Immature stock will have to be sacrificed for some time in order to maintain a sustained yield. The present Simple Coppice system has worked successfully in the past and most of the working plans shall have to continue that system. But there are large areas where conversion from the coppice to the high forests is possible and can be attempted with a consequent increase in volume of the growing stock. Beginnings are being made. Working Plan Officers have been appointed and are now writing the preliminary reports for the valuable teak and sal areas. The work is expected to gain momentum as the staff gets training in this work.

Forest Organization

The Department is in charge of a Chief Conservator of Forests who is also a Joint Secretary to the Government. There are at present seven territorial divisions, two working plan divisions and a soil conservation unit as compared to only five territorial divisions a year ago. Appointment of a Conservator of Forests for working plans and development has been sanctioned and an officer will be appointed shortly. There are 31 Rangers, 73 Assistants' Circles and about 1,000 Forest Guards' beats. The present sanctioned strength of the department is as under :—

Chief Conservator of Forests	1
Conservator of Forests	1
Divisional Forest Officers	8
Working Plan Officers	2 (1 temporary)
Divisional Assistants	8
Asstt. Working Plan Officers	2
Manager Shellac Factory	1 (temporary)
Personal Asstt. to Chief Conservator of Forests	1
TOTAL	24

All ranks of the staff are being trained regularly. One officer of the Superior Forest Service, four Forest Rangers and 8 Range Assistants are being sent out for training every year.

Lac Cultivation

Vindhya Pradesh ranks third in India in the quantity of lac produced by it. It is the only State where the work is done by the forest department from the initial collection to the finished product stage. The collection is done by '*Baigas*' a forest tribe and crude lac is stored in the godowns set up by the Department. There are 76 such godowns in the State. The stored lac is spread in big airy rooms and dried. It is then despatched to the factory at Umaria where it is manufactured into seed lac and shellac. The former process has been recently mechanized. The sale of both these products is by public auction. Provision exists in the current five-year plan for manufacturing oil cloth, sealing wax and various other articles. Machinery for the purpose is being ordered.

Forest Tribes and Shifting Cultivation

In the remoter areas of forests the population is scanty and the inhabitants consist of forest tribes living in these regions since times immemorial. Their agriculture is of the crudest and shifting cultivation is still practised. The settlement of these tribes in the more accessible localities in forest villages is one of the items in the current five-year plan. Much progress has not, however, been made. The item will figure more prominently in the second five-year plan.

Soil Conservation

Like most parts of India the importance of Soil Conservation is being felt all over the State. The Govt. are alive to the dangers of soil erosion and are prepared to undertake any measures that may retard this destructive process. A pioneer attempt in the reclamation of ravine areas along one of the destructive rivers in the State, the Sindh, made last year has borne fruit and has been of great value in awakening public conscience in this very important work. The technique is simple. An area of 2,000 acres of the ravines has been honey-combed with earthen check dams of various sizes. This aimed at creating as many "pockets of water" as possible, in order firstly to decrease the flow of water and secondly to have fresh silt deposited over as much area as possible. The sizes of the dams varied from $5 \times 5 \times 5$ feet to $100 \times 20 \times 15$ feet, i.e., from 125 c. ft. to 30,000 c. ft. All this was done during winter. The soil was loamy clay with layers of lime kanker. The fear was that they would be washed away during the monsoon rains and the success of the experiment depended on how effectively they could withstand these rains. A gang of labourers was appointed at the break of the rains to repair any breaches that took place. That the dams withstood not only the ordinary rains but the unprecedented rains of the current monsoons was a pleasant surprise. The result is that where there was desolation we now have tall grass. The seeds sown have germinated and the existing heavily browsed trees have produced fresh shoots. Needless to say that the whole area is closed to grazing of all kinds. The work is being further extended this winter and has been taken up in various other parts of the State. The experiment has been filmed and will be released as a documentary very soon.

There are various other schemes which are under execution. The reclothing of the bare hillsides is one such scheme. The *modus operandi* is the construction of interrupted contour trenches, sowing them up and leaving the rest to nature. The results have been encouraging and large scale works will be undertaken shortly.

Wildlife

The forests of Vindhya Pradesh abound in game. The tiger, the panther, the bison, the majestic *sambhar*, the *chital* (spotted deer), the *chinkara* (Indian gazelle), the four horned antelope, the black bear and various other animals are its denizens. The tiger takes the pride of place amongst wild animals. It is the noblest of animals and provides the finest sport. Tiger hunting has been known in our country from times immemorial and, though the aboriginal tribes still hunt it on foot with their crude weapons, the modern practice is to hunt it from a *machan* (a small platform erected in the upper branches of a tree) or from elephant back. This sport provides the thrills of horse racing coupled with the hazard and suspense of a roulette table in Monte Carlo. The hunt is carefully arranged and planning starts days ahead. The haunt of the tiger is located by following the pug marks and baits (usually buffalo calves) tied on the track. As soon as the 'kill' takes place, a beat is arranged and *machans* are erected at a convenient opening in the forest. These are usually placed at spots where the tiger is most likely to emerge. The tiger after eating his fill rests nearby and the skill of the beater lies in waking it and directing it towards where the guns are waiting on the *machan*. The tiger treats the beaters with the utmost contempt and is usually in no hurry to break cover. In a well organized beat the tiger's retreat from its resting place can be arranged on previously determined paths. Too much or too little noise can easily spoil the most well planned of beats. The slightest whisper or noise from the *machan* might easily result in the tiger retreating and attacking the beaters. The greatest caution has therefore to be exercised. As soon as the tiger breaks cover and comes into the clearing opposite the *machans*, the guns boom and the tiger is laid to rest. After this all is pandemonium. The beaters celebrate by dancing, the villagers come out in large numbers and the tiger is taken out in procession. The panther on the other hand is a different proposition altogether. He is the most cunning of animals but his undoing is his insatible appetite. The usual method is to tie the bait (generally a goat kid) which keeps on bleating till the panther hears the sound and comes for it. The gun is sitting in a *machan* over the kid and the panther is killed before he has even time to pounce on the kid. But, more often than not he manages to kill the bait and even eats a part of it before the gun can take aim and fire the fatal shot. Panther is also shot by sitting over the animals he has killed, but he is so clever that the preliminary preparations usually make him suspicious and he does not return to the kill.

Amongst the herbivora the bison provides fine sport. There is only one forest block (Ghunghuti) where these animals are to be found but sportmen are discouraged from shooting them as there is danger of their becoming extinct. But they provide good sport for the cameraman and provide thrills unequalled in the tiger and panther hunts. The *sambhar*, deer and the antelope are also good sport for the *shikari*. Parts of Vindhya Pradesh teem with them and the farmer finds it hard to protect his crops. Their hunting has a thrill of its own. The deplorable practice of shooting herbivora with dazzle lights is gradually dying out as game preservation laws are being more and more strictly enforced. Stalking deer, antelope or *sambhar* in the early morning has thrills rarely equalled by any other form of sport except, of course, the tiger hunt. A knowledge of the habits of these animals is essential for stalking. Hunting them with a camera also has its charms and is strongly recommended to really good and keen photographers.

All species of birds abound in the forest. The quail, the partridge, various kinds of ducks, the stork, the wild fowl and the green pigeon provide excellent sport. Last but not least is the crocodile to be found in most of the streams. In winter one can find them by the score. A few alligators are also found but they are preserved and their shooting is strictly prohibited.

The Five-Year Plan

Occasional references have been made to this Plan. A great deal of work has been done under this Plan. Over seven hundred miles of fair weather roads and many buildings have been constructed. A Forest Guards' Training School and a publicity unit with full equipment is already working. Proposals are afoot for starting a lion sanctuary and a white tiger sanctuary. Forest industries are also being considered. Negotiations for the start of a factory for the manufacture of tannin extract from myrabolans have been completed and the factory will go into production in a year or so. A survey of the various resources available in the forests for the start of a paper and rayon factory, a plywood factory, and a big saw-mill for railway sleepers are already in progress. These items will receive attention in the second five-year plan. A big afforestation programme in the denuded areas of the Tikamgarh and Datia districts is being formulated and will also form part of the second five-year plan.

Conclusion

A beginning has been made, something has been achieved but a great deal remains to be done. With hope in one's breast and faith in one's destiny, the Vindhya Pradesh Forest Department may yet prove to be the "*enfant terrible*" amongst the forest departments in India.